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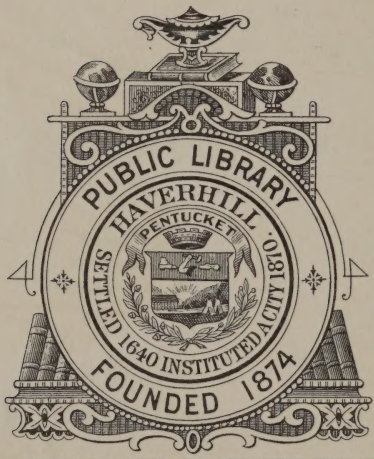

NATHANIEL E. NOYES FUND

THE

TECHNOLOGY

OF

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BY "CREPIDAM."

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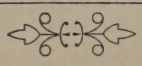

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THE

TECHNOLOGY OF BOOT AND SHOE MANUFACTURE.

INTRODUCTORY.

PURPOSE AND METHOD OF TECHNICAL INSTRUCTION.

It is now seventeen years since Hill's "Manual of Boot and Shoe Manufacture" first indicated the path for a handbook for technical schools. Much water has flown under London Bridge since that time, and the course of the shoe industry has deviated not a little. In its essential principles, boot and shoe manufacture is now what it was then. The principles have not altered, but the processes have, and with the new processes new and additional principles are involved. That book by no means exhausted all that might then have been said about principles, nor even of current trade processes. What it did do was to indicate a method by and through which the vast subject of the technology of boot and shoe manufacture could be approached, and it was itself an outcome of the technical school movement originated at the Polytechnic under Alfred Hannibal. The then existing handbooks of Rees, O'Sullivan, and Devlin and the pamphlets of Meers were confined to a study and explanation of purely manipulative processes. In their day the McKay machine had not made its appearance, and the modern revolution of shoe manufacture started by Howe with the upper-stitching machine, and continued to a new era by the sole-sewing machine, left these early writers hopelessly out of date.

The upper-stitching machine, the sole-sewing machine,

and the modern high development of the machine-welting process mark the three stages of the development and progress of modern shoe manufacture; and in this growth there is indicated the need for a new text-book that shall make at least some attempt to represent the facts of this development, and to throw some light upon the principles that are involved in it.

Not that the trade has been left without its witnesses in the interval that has elapsed since Hill and Yeoman's "Manual" was first published. How ably the many writers who are contributors to trade journals have striven to record new improvements, and indicate developments of old methods, a perusal of their pages for the last 15 years will testify. Handbooks treating of sections of the trade have helped forward the work; but as yet no complete handbook has appeared, though I believe many have been projected.

If, however, there have been witnesses by the written word of the development of this industry, there has been a still more potent factor in the wide development of technical schools and of organised schemes of technical instruction by means of lectures and demonstrations.

Twenty years ago, but one technical school for shoe people existed. To-day we have the not unimportant development of the Bethnal Green School, which has taken on new vigour under the present head-master. That this is due to a greater loyalty to the gospel of the once-despised Occident, of that we need make no complaint. To-day it is doing a good work, and that is sufficient. This period has seen the epoch-making development of Northampton, the establishment and growth of the work at Leicester, at Bristol, at Norwich, at Wolverhampton, and Glasgow, and even the Irish, in a more or less inadequate way, have had the gospel preached unto them.

The time to which I have already referred was one of active enquiry. Every month, almost every week, new machines and new appliances were being introduced, and, these perfected, have called for the adaptation of old method to the new condition, and for the introduction of entirely new processes, t wenty years ago then undreamt of. These conditions are being repeated to-day. There has been a fresh outbreak of invention, and a continued necessity for fresh adaptation of means to ends that can only be adequately and speedily met by technically trained minds.

For the due training in the technology of shoe manufacture there is need for an upgathering of the ideas that have been sown and grown in these schools, and in all the wide

associations of them, and this will be a further purpose of the present work. For what have been the principles underlying these efforts we speak of as technical education; and what has been the net result upon the actual operations of boot and shoe manufacture of the application of these principles?

Technical education, wherever it has been conducted in a worthy manner, has been concerned with the scientific and artistic principles underlying the shoe industry; but, whilst it has been concerned with these, it has never for one moment lost sight of the objective purpose, and that it has not lost sight of this is plain from the improvements clearly seen in the present conduct of the industry.

That this movement and the circulation of the ideas that have been disseminated by and through it have had a marked influence for the good of the trade is beyond all question. They have been the soul of all improvement in the shoe industry. Just as all social reform has been preceded by a revival of learning, so may this movement in relation to the progress of the industry be likened to the renascence and the reformation. Revolutions are in idea before they are in act. A comparison of the present products of the shoe manufacture with the productions of twenty years ago establishes this truth; and in the modern product we find the determining influence upon the shoe manufacture of this technical education movement. Of these influences not the least marked have been those proceeding from the thought of the men of science. Apart from actual methods of manufacture, the greatest difference between the shoe of to-day and a quarter of a century back is associated with an improvement in the form and shape, with the direct consequence an improvement in the "fit"; and if only goods fit the feet, almost every other grace and quality is added unto them. And who, it may well be asked, has exerted a greater influence in this direction than Professor Meyer—the author of "Meyer's line," the foundation of all our reasonings regarding insole shapes and the fundamentals of last construction?

It is remarkable that the study of the form of the foot and the method of its classification had until his day been almost entirely neglected by anatomists and anthropologists; and, indeed, with a slightly lessened force, this is true to-day.* Apply to the London Anthropological So-

* A good example of the absurd reasonings that pass in many scientific works treating the foot may be found in Havelock Ellis's "Man

ciety, and you will be referred to bootmakers; and from Berlin you may know a heap about negro feet; but of the white races, both learned societies appear not to know anything.

Reverting to Professor Meyer, one has to say that the full measure of his teaching, and the reasons wherefor in some degree the whole of his teaching has not been received, have formed a very important part of the instruction given in shoe trade classes; with the result that whereas twenty-five years ago boots and shoes were, as to their sole form, almost universally bilaterally symmetrical, with the result that every adult person had an everted great toe. Now, if, instead of viewing each foot as complete in itself, we view each foot as the complement of the other, then what the old craftsman, with his mistaken idea of the shape of the foot, tried to do for the single foot, we shall do for the pair viewed as a unity. And for this improvement, not alone the trade, but the entire community, owe to Meyer and to the shoe trade classes and technical publications through which his ideas have been spread, a very deep debt of gratitude.

I think it may safely be said that 75 per cent. of the middle-aged population of England have everted great toes, and all the ills and troubles that follow in their wake; and, whilst this is so, it may also safely be said that of the rising generation one need not expect a greater percentage of defective feet from this cause than 25 per cent., owing to the present improved shape of even the very cheapest footwear.

The most marked influence of technical teaching has, then, up to the present concerned the "form" of boots and shoes, and this has, of course, involved improved methods of last arrangement and pattern cutting. These things in the old days were viewed as separate entities; they are now, in the light of technical teaching, seen to be parts of one organic whole, whilst geometrical applications have made of pattern formation and grouping an applied science.

Not the least of the advantages reaped by the public is the present ability to purchase shoes that will not prove to be active agents in wearing out the stockings, and that need no bits of velvet in the back, or extra eyelets in the quarters, for the accompaniment of this end. For shoe

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and Woman," p. 53 et seq. See also Ottolengni v. Carrara. "Il Piedeprensile negli Alienati e nee Deliquetti," Arch. di Psichiatria, 1892, Fasc. IV., V.

fitting, in the light of the new knowledge, is seen to be a question of last formation and of last fitting, and not of adventitious additions to the finished shoe constructed on an ill-formed last.

The right principles for the formation of the built heel have been demonstrated, and a reason given, from a study of the osteology of the foot, why there should be a difference in the length of the sides of the heel, as in common practice is now recognised as right and proper. We have said good-bye to stiff, thick-waisted boots. It had, however, first to be shown that this stiffening of the waist was the survival of a practice due to a necessity now no longer prevailing, and this was an office of technical education. The true principles wherefor boots and shoes are made longer than the foot have been scientifically determined. If it be argued that this was already known, one has an easy refutation of that position by pointing to Dowie's book, published thirty years ago, wherein, on this point, grossly inaccurate statements of what is claimed as the scientific position are made, endorsed by a Fellow of the Royal Society, and passed as the best practice of that day; and so one could go on demonstrating the objects that have been attained by and through this movement, and these, in more detail, it will be an object of the present work to show.

Improvements in leather manufacture, due to the researches of scientists, themselves a product of this propaganda, have assisted the shoe manufacturer, until to-day the English shoe trade has no need to be ashamed of its products, nor afraid of any competitor.

There are still large fields of knowledge yet unconquered, but, seeing that every idea, whilst it is the "resume of the past, is but the germ of the future," this future will be made the more speedily prolific of good by the due marking of the present position attained, and this will be a final object of the present work on "The Technology of Boot and Shoe Manufacture."

Chapter I.

METHODS OF OBSERVATION AND RECORDING THE FORM OF THE FOOT.

The methods of observing the form of the foot are many —some elaborate, and others more superficial. The methods employed, and their usefulness, must be measured by the object that it is hoped to attain by them. It has been said by an eminent French chemist that the whole of modern chemistry consists in measuring and weighing. If a true science of the foot and its structure is to be developed, then the methods for its observation cannot be too complete or too minute; neither can the number of measurements, or the amount of data, collected concerning it be too many or too elaborate. For so will be upbuilt a true knowledge of the foot's form that will permit of the more correct interpretation of the coarser methods necessarily involved in the daily practice of the bespoke department, or of the factory. And, indeed, herein lies the hope that by the due compilation of accurate facts concerning the types and measurement of feet, bespoke work will become a thing of the past for all other than malformed feet.

It cannot be too often insisted that correct fitting of shoes and boots to the foot depends less upon their actual and close correspondence to the detail of the external measurement of the foot, but everything upon a true and corresponding shape or form. In pattern-cutting it is a safe rule, wherever there is an apparent conflict between the demands of the measurement and the shape of the pattern, to unhesitatingly sacrifice the truth of the measurement and maintain the correct form, and there is no shoemaker or shoe manufacturer who has not in his collection of lasts a wonderful set that seems equally successful on a range of feet with external measurements widely different. He calls such a set a "good-fitting last," which is but to say that it represents a truer mean shape than some others, and

emphasises the value of correct form as opposed to minute accuracy of measurement.

That such a correct "form" shall be evolved, it is desirable to use all the means that are in our power in the observation of the form of the foot. This is to avail ourselves of the method and spirit of the "research" worker in the shoe factory; and, if "research" work is desirable in other industries, it would be interesting to know for what reasons it is undesirable in the shoe manufacture.

If, then, some of the methods for the observation of the form of the foot about to be described appear elaborate, if they be regarded as methods for the scientific observation of the foot, so much of the method may be selected as commends itself as practical for use to the individual need of

Fig. 1.

the person requiring such methods for everyday trade practice. It is needful that all methods should be known, and this knowledge we shall endeavour to establish.

In order to get a complete knowledge of the external foot, it is first necessary to know something of the bottom surface. This information is obtained mainly by means of impressions, or by direct prints obtained from the bare foot. We will treat first of direct prints obtained from the bare foot.

Printers' Ink Method.—Ellis gives a print (reproduced here in figure 1) obtained by smearing the sole of the foot with printers' ink.

Vaseline Method.—A very good method, much more cleanly, is to smear the sole of the foot with vaseline and take a print on smooth cardboard. Such a print is given in figure 2.

Charcoal Method.—Another method described by Herr

Zintgraff* is to put the feet in wet charcoal before taking a print and tracing upon plain paper. It is doubtful if everyone would succeed so well with this process as Herr Zintgraff. In his prints, the charcoal powder clings firmly to the paper, and gives a good image of the superficial track. This method was introduced by the late Major-General Starke, and is the one taught in the School of the Shoemakers' Guild in Berlin. Great precautions need to be taken in using it, as the result depends very much upon the degree of pressure brought to bear upon the foot; the same foot will make an extensive or partial reprint according to the amount of this pressure.

Paste and Colour Method.—The following is another German method. On a sheet of paper, wet with paste, place another sheet of thin paper, whose lower or under surface

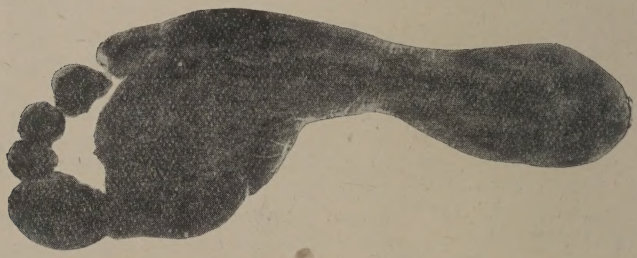

Fig. 2.

is covered with aniline colour. Place the naked foot upon the two sheets of paper so placed, and on the paste there will be a clear imprint of the foot track.

Of course, this latter is not a direct print from the foot, and is more properly an impression, and it is of impressions that we will treat in more detail.

The method of smearing a plain sheet of writing paper with aniline colour, and, when dry, laying it upon a sheet of wet millboard, is one of the earliest means for taking an impression, and is, of course, well known. This method has in modern practice been developed with the idea of making the materials readier for use, and three or four variations of the method are given in the Northampton Technological

* Berlin Anthropological Society Proceedings, session January 19, 1889 (on the feet of Wei and Kru negroes. See also session March 20, 1886; October, 1888, and a very interesting communication by the renowned Virchow, Proceedings January 17, 1885.

Handbook, the most important variations beings as follow: Make a strong solution of aniline dye in alcohol, adding about an equal bulk of glycerine. In this soak some moderately thin white blotting paper, and allow it to drain. The paper so prepared is used like ordinary carbon paper.

A further method is to make a solution of iodine in potassic iodide, or alcohol. Moisten the upper surface of a blotting pad with this. Then place over it a piece of white blotting paper which has been soaked in starch and dried. Place the foot on this latter paper, and a deep blue impression is obtained.

Other methods having a like result are detailed, and the

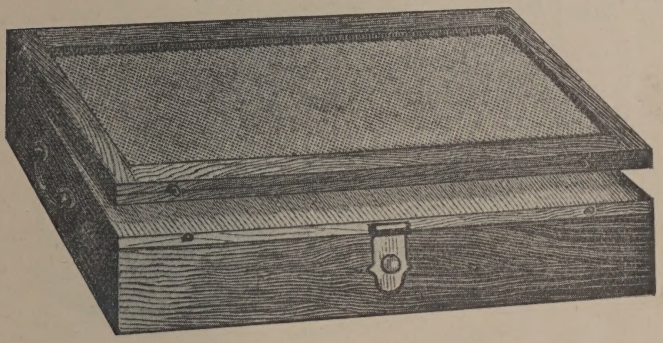

Fig. 3.

reader is referred to that book for the remaining of these methods.

The main objects of impressions is to secure a record of the amount of the sole or palm of the foot having contact with the ground. These facts are obtained, of course, with the direct prints in the fullest manner. In them one also gets some rather full details of the character of the skin of the foot which cannot be obtained by an impression. A knowledge of the amount of contact surface is the main purpose of both direct prints and impressions, so that a really good impression is almost as satisfactory as a direct print.

For obtaining impressions, certain details have already been given. The method, however, which best fulfils all the conditions for this purpose is that explained in the "Manual of Boot and Shoe Manufacture" (p. 24, Third Edition, 1900) by the apparatus shown in figure 3.

A further method of observing the under surface or palm of the foot is taken from the "American Journal of Orthopædic Surgery," and, whilst very simple, is at the same time very ingenious. It is by means of a table with a glass top.

Dr. Ellis* has also devised a method for securing the contour lines of the sole, which is described as follows:— The apparatus used is called a "Pedistat." It consists of

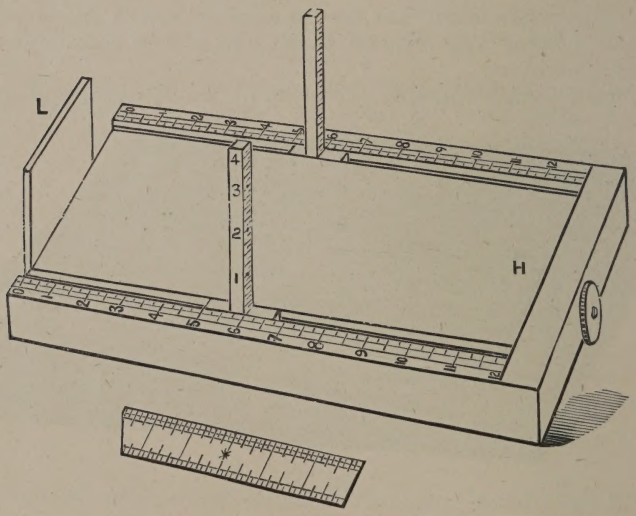

Fig. 4.

wood, and has a middle platform twelve inches long and four wide. At one end of this is a block, against which the heel is placed. Outside the two borders of the platform are sunken grooves, along which slide two upright brass pillars; the inner edges of these also maintain a distance of four inches apart. The margins outside the grooves are graduated in one-eighths of an inch, dating from the heel-block. The pillars are similarly graduated, dating from the platform level. These pillars slide by means of a running screw, moved by a round milled head, seen in front. A 6in. brass rule is provided, marked on the middle by a star; but the inches are not marked. This is so as to measure either from the end of the rule or, when sliding in the grooves of the two pillars, from the first inch. The corner

* "The Human Foot" (J. and A. Churchill), 1889, p. 102.

is cut off at one end, but not at the other, so as to afford a pointed or a square ending as desired. Both sides are graduated alike, the longer edge being bevelled, so as to run in the grooves of the pillars. When these are set at any place in the length of the foot, the brass rule bridging across from pillar to pillar will fix the exact position of the highest point of a section across that line. By this apparatus can be indicated the length from the heel-block (L), its height from the platform level (H), and the distance from the inner or outer border of the four-inch platform.

Fig. 5 shows a sole outline taken on the "Pedistat." The extreme length being marked by stretching the rule from pillar to pillar, numberless sections of the foot may be made by the use of this apparatus. Its main defect is that

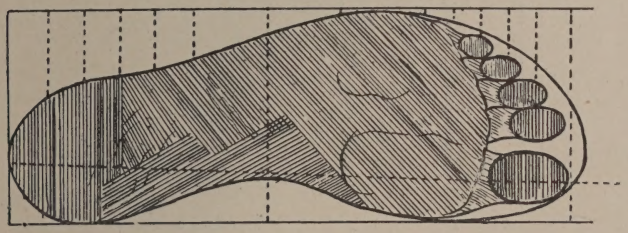

Fig. 5.

it gives no indication of the curvature of the palm of the foot. Some means for indicating and recording the shape of the underpart of the foot is highly desirable—nay, absolutely necessary. Herein it is that feet so much differ, and upon the basis of this curvature, its extent or absence, all classification has to proceed. The perfect recording machine will also provide that this shall be done.

If the base of Ellis' Pedistat was made in transverse sections (that is to say, the four-inch platform), one-quarter of an inch wide, divided in the middle, with means for raising these sections to fit up exactly to the palm of the foot, a means would be provided in an apparatus so designed for obtaining all details concerning the shape and form of the foot.

Such, then, are the methods for the natural delineation of the sole form and the sole area, and partly for obtaining a knowledge of its "form."

The other method whereby the form of the foot may be studied is by the

COLLECTION AND COMPARISON OF GIRTH MEASUREMENTS.

About the methods for taking the girth measurements of the foot, some account must now be given.

The cardinal principle is to indicate the location of the girth measurement. The general method is to use a location tape, as shown in the diagram, figure 6.

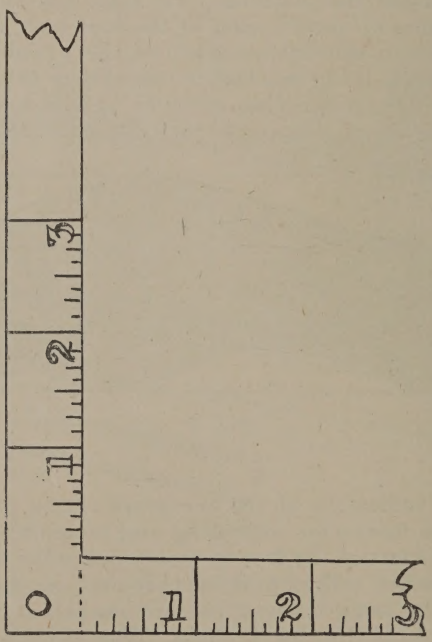

Fig. 6.

Another method is using an ordinary tape, to use same in conjunction with an impression plan. The foot is placed upon an impression paper having straight lines drawn across it. The ordinary joint instep and heel measures are taken quite tightly, and in the direction of one of the transverse lines. At the particular line used, a mark is made, and the exact girth measurement at that point indicated. The method is shown in figure 7.

Many other methods are shown in the elementary text-books. The length is taken, of course, by a size-stick;

and about this it need now only be said that care is required in the selection of this tool.

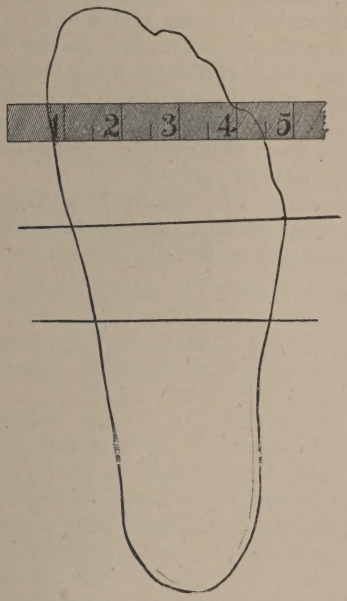

Fig. 7.

Several systems of upper pattern construction are based upon the nature of the angle the foot makes with the leg,

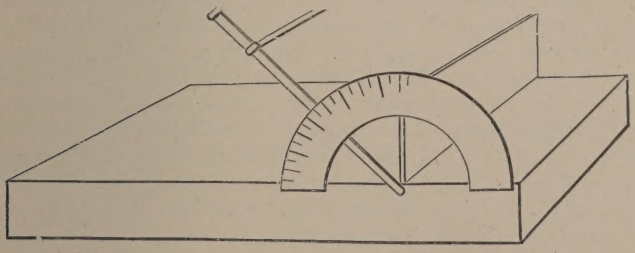

Fig. 8.

and it thus becomes desirable to have some method for ascertaining the degree of this angle. There are several German systems of Pattern-cutting having as their basis

such a heel angle, and Meilli, in his "Fuss der Fussderbeinling," illustrates such an apparatus, as shown in figure 8. It consists of a flat board with a protractor at the heel end, and an adjustable pointer with a sliding index moving along, and fitting to the "throat" of the foot, and thus indicating the degree of the angle upon the protractor.

The same facts may be obtained through the use of a location tape, using the tape in such a manner as to indicate the distance from the ground, upward, that the tape in measuring the heel has passed.

So much, therefore, for "Methods of Observation." In a succeeding chapter we will hope to state what of practical import may be learned by the use of such methods.

Chapter II.

THE FORM OF THE FOOT.

What is the form, and what are the characteristic features, of the foot? This will be the subject of the present inquiry.

"Characteristic" is a word of common English speech derived from a Greek word signifying a stamp, mark, or character. What is the "foot," or a "foot"? In comparative anatomy the word has a very loose usage. Sometimes, as among insects, the "foot" is a leg, and even scientific naturalists so designate these. With the Rotifera it is a caudal process or tail; whilst with the molluscs it is a ventral disc; and so on. The word "foot" is not strictly a scientific word at all, but one borrowed from common speech and popular usage. The term "foot" strictly has reference to the human foot, and the one thing clear and distinct about it is that it is not a hand; and it is of the characteristics of this human foot we have now to treat.

Now, the first of these knowledges of the external foot is obtained by a study of the form, and by its close observation in action. The methods open for its observation have already been dealt with in the previous chapter. Methods of observation are indeed specially necessary to the manufacturing community, seeing too little of the ultimate results of its labours, and tending too often in this matter, if one may distort the poet—

> To lose sight of the goal
> In the dust of the racing machinery.

Just as it would be the height of unwisdom to attempt to build a house without first sitting down, studying the requirements of the proposed inhabitant, making a specification, and drawing a plan, so much is it unwise and a limita-

tion of the best effort to endeavour to construct a boot, without first thinking well of all the peculiarities of the member who is to inhabit it. In the future, every technical school should be furnished with an anthropometrical laboratory, that these observations may be codified.

With the material on this point already gathered, let us now see what, through these things, we may learn of the structure of the human foot.

It is generally stated that the feet are the counterpart of each other. This, we think, will be found not strictly true. Close observation of a large number of feet establishes the fact of a slight difference in the disposal of the stuff composing them, giving a slight difference to the form of the left foot. This will be found to be very slightly wider, slightly larger in the ankle, and very slightly shorter than the right foot. These differences are usually very minute, with a continual tendency, however, in a pathological condition to emphasise these differences between the two feet. That is to say, in ill-health it will much more often be found that it is the left foot, and especially that it is the left ankle which is the larger.

Subject to what has been indicated, it may be said quite safely that the feet are the counterparts of each other, and, whilst a correct form is given to the lasts, these differences are so minute as to establish no need for girth differentiation in the right and left lasts. But, if the feet are the counterparts of each other, they, nevertheless, cannot from any point of view be considered singly or alone. Whatever defect may be seen, or thought to be seen, in the single foot is supplemented to the point of obliteration by viewing the two together. Dr. Hepburn has stated that the spot over which the inferior calcaneo scaphoid ligament extends—i.e., at the lower ankle joint—is the weakest on the foot, the astragalus being there unsupported by any bone. This has frequently been referred to as faulty structure. If this spot is not supported by any bone, it is, however, afforded additional support by the tendon of a strong muscle, the posterior tibial (shown in figure 9) which passes from the back of the big bone of the lower leg (the tibia) round the inner ankle to be inserted into the lower part of the inner surface of the scaphoid bone.

The defect known as weak ankle frequently arises from the overweighting of the astragulas causing it to fall below its proper level, lowering the arch and flattening the sole of the foot. When this defect is still more decided, it is termed flat-foot, and in extreme cases the bone may fall to

such an extent as to render the inner side of the foot convex, whereas naturally it should be concave. It also arises from a malposition of the great toe displacing the relationship of the whole group of bones making up the foot. The malposition of the great toe is effected frequently enough by health, it is imperative it should have rest. Such rest is obtained in the intervals between steps, and it is a most important matter. "The period during which the foot is uplifted from the ground may appear so small as to be of no appreciable value for rest. This is not really so. The

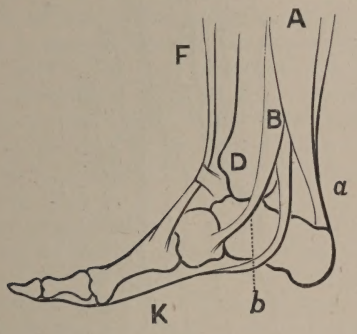

Figure 9.

A, the gastrocnemius and soleus muscles, forming the muscles of the calf; a, the tendo Achillis; B, the posterior tibial muscle; b, its tendon; D, the inner ankle; F, the anterior tibial muscle, attached above to the front of the tibia below to the internal cuneiform bone; K, the flexor tendon of the great toe.

muscles concerned in respiration get no rest beyond that obtained between the inspirations; the heart, a muscular organ, only that between the beats. Yet rest, for muscular action, is necessary, and is in each case sufficiently supplied."* In prolonged standing in one position, no rest is afforded the ligaments of the foot, and a breaking of the arch is the consequence.

But if the feet themselves be regarded—as in truth they must be regarded, and as by the shoe manufacturer they must be regarded—as supplying the deficiencies of each badly-formed footwear, but quite possibly more often by a bad use of the foot. Prolonged standing in one position with an unclothed foot would inevitably induce fixed ad-

*See W. A. Lane, M.S., "Clinical Journal," August 7, 1895.

duction of the foot.* For the maintenance of the foot in health, here, with Ellis, we may at once "admit a deficiency in the single foot, to be supplied, and which, in fact, is supplied, by the other."

A line drawn from A to B (figure 10) passes on the outer-side of the third toe, through the foot, and along the outer side of the heel bone. Such a line cuts off the two outer

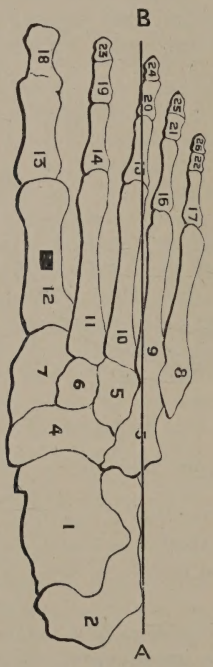

Figure 10

toes with the part of the foot behind them, and in front of the heel. The area thus cut off by this line forms a kind of set-off in the ground plan to the main structure. Beyond this line but one bone obtrudes (the cuboid), and, this being connected with the two outer toes (the two outermost metatarsals articulating with the cuboid bone), serves to connect these with the part receiving the downward pressure of the body. There is reason, therefore, in this for-

*T. S. Ellis, p. 70.

ward expansion of the foot, for thereby is secured in reality a support or buttress to the main structure deliminated by the line A B (figure 10). Now, just because of this buttress-like support, and forward expansion of the outer side of the foot, no such aid or influence is needed on the inner side, for the equivalent of this is more than supplied by the other foot. The observation of this feature not alone supplies an answer to the contention of weak structure on the inner side of the single foot; it also supplies an anatomical basis for sole pattern construction.

All methods of sole pattern construction have, as their fundamental, a parallelogram, corresponding to the demarcation on figure 10; that is to say, the shorter side of the oblong is always the width of the seat of the heel, and the longer side is the length of the foot, leaving the outer, or buttress-like, portion to be dealt with according to various theories, such as Camper's, Meyer's, Hannibal's, of varying truth and merit.

The front or expanded part of the inside margin of each foot is seen to be almost straight. That is in an uncorrupted foot. But, as Virchow has reminded us, it is "well to know that the foot is disposed to so much deformation among all people who wear shoes or boots, that you can only find a natural foot among new-born or children of a tender age. Even the sandals, if worn constantly, press the toes together and form a lasting deformation. In vain may you look for regularly-formed feet among the Greek statues of marble; the gods of the Hellenes had compressed toes."*

The outer margin, as we have already seen by a study of the form of the foot, describes a bold curve, and acts as a buttress to the main structure. It also ought to be observed that, from the fact that the main weight of the body is transmitted through the bones of the leg ultimately to the cuboid bone, this is a sufficient reason why boots tend to tread over on the outer side, and that it is an additional reason why they should be of the right and left form.

A section of the hinder part of the foot, through the ankle, shows no lateral expansion. The outer ankle is narrower, comes lower down, and is situated farther back, than that on the inner side. There is a considerable range in the variation of the height of the outer ankle measured from the ground, depending very largely upon the extent of

* With regard to classical sculptures, Ellis is at one with Virchow. See pp. 52 and 53 of his book.

curvature existing in the arch. This variation may be as much as half an inch in a group of male feet.*

The inner margin of the foot is markedly thicker and higher from the ground than the outer side, and, moreover, has no lateral expansion. The medial part of the inner margin is raised up from the ground, forming the longitudinal arch, and emphasising that which is, undoubtedly, the dominating feature of the human foot, the specially developed great toe.

It is indeed the most remarkable feature of the human foot, differentiating the foot of man from that of all the

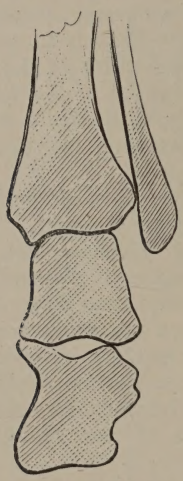

Fig. 11.

lower animals. As a rule, in all mammalia the outer cuneiform bone supports the third or middle of the five toes, when they are all present, the middle cuneiform the second, and the cuboid the fourth and fifth. The hoof of the horse is the ultimate development of the bones articulated with the outer cuneiform, and marks in this form the domination of the third toe. In the rhinoceros there is one principal toe, the third. In the elephant, however, we find a fifth digit, but yet still with the third toe the most prominent.

Thus we find that only in rare instances is every digit represented in the other mammals; but, wherever it is

* Professor Virchow, "Proceedings Berlin Anthropological Society," January 17, 1885.

found, it has always this peculiarity—a third bone is never found in the first digit, in the one represented in man by the thumb and great toe.

Ellis appears to think that in man it is in reality the first metatarsal that is missing; whilst Owen concludes that the course of the simplification of the five-toed foot is, first, a diminution and removal of the innermost toe, and, next, of the outermost; and, from certain facts recently made

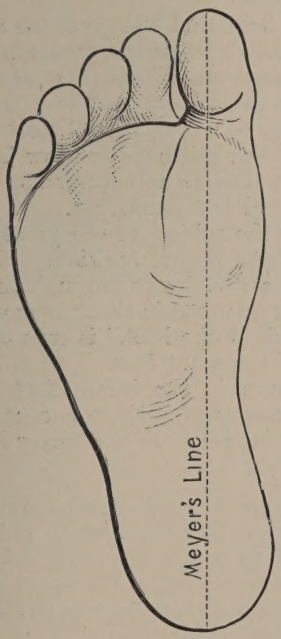

Fig. 12.

known concerning the fifth toe in man, Owen's explanation appears to be the best supported.*

* Pfitzner finds there is a tendency for the little toe to possess only two joints, the middle and end phalanges being welded together. This result is not artificially produced, as it is nearly as common in the embryo and the child as in the adult. There appears to be at the present time a progressive, or, as Pfitzner regards it, retrogressive, development of the little toe; though it should be added that in such a matter the degeneration only applies to the particular part, and not to the organism generally. The course of higher evolution has

Whatever may be the truth of the details of the evolutionary process, certain it is that man has a remarkable and distinctive great toe, and hence a distinctive foot. Professor Humphry has stated that, in the animal kingdom, "man literally stands on his great toe"; and Dr. Hepburn: "The great toe is remarkable in man for its size and strength, and for the firm manner in which its metatarsal is joined to the other bones so as to render it the main support of the foot."

It is generally held that the great toe is longer than the second. Very probably this is a question of sex. The tendency to the greater prevalence in women of a long index finger appears to be accompanied by a similar, though less constant, tendency to a long second toe.*

These facts, as we shall hope to show later, are not without importance to shoe manufacturers, and have not a little to do with practical last formation.

Before leaving the subject of the great toe, one ought to say something of its normal position. The rule of Professor Meyer, "that a line drawn through the whole length of the great toe, if continued backward, should emerge at the centre of the back of the heel," is true of the infant foot, but not so true of the adult foot.

The plantar arch in the infant foot is almost absent. With the development of it there is a corresponding slight eversion of the great toe from the Meyer line.

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always been accompanied by the disappearance or degeneration of particular organs and parts no longer needed. It is interesting to note that women seem to be leading this movement. Among 111 feet of men and women, 41.5 per cent. of the women showed fusion of the joint, and only 31.0 per cent. of the men (W. Pfitzner, "Die Kleine Zehe," quoted by Havelock Ellis).

* Park Harrisson found that the second toe tends to be longer in women than in men ("Journal Anth. Inst.," vol. xiii., 1884). Papillant found in Paris a very slight excess of women among individuals showing a longer second toe (18 per cent., as against 16 per cent. men). Stratz believes that the best developed foot shows a longer second toe (regardless of sex). Weissenberg notes that ancient Greek statues usually show a longer second toe. The Papuans tend specially to have a long second toe. Lombroso found in every group examined at Turin shorter big toes among women than men (see Havelock Ellis, chapter "Growth and Proportions of the Body"). Flower ("Fashion in Deformity") examined hundreds of bare feet among children (it should be noted they were children's feet), and could not find one in which the second toe was longer.

The greater the distance separating the great toe from the second, the more prehensile the foot and the lower its character. The power to separate the great toe from the second appears to be more marked in the female than the male.

As well as the longitudinal arch already referred to, there is a transverse arch formed, structurally, by the three cuneiform and the cuboid bones. These bones form a transverse arch in each foot; the two feet together give a hemispherical shape, as shown in the figure.

There is also a small transverse arch formed in the palm of the foot. This must be noted now, as it has a very important relation to the form of the bottom of the last, and

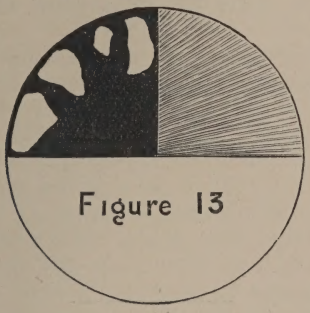

Figure 13

a bearing upon the vexed question of bottom-filling and "feather" curling, to be considered in due course. Viewing the two feet together, the vault of the dome is found to be more expanded lengthwise than breadthwise. The diameter lengthways is more extended in the front than at the back.

There are some special points in connection with the form of the foot emphasised by a study of impressions. The first of these is the very great convexity of the heel. In an impression of the foot, but a very small print is made, relatively, by the seat of the foot, even under pressure. The particular application of this fact will be dealt with when dealing with last-formation and pattern-cutting. A further fact to be noted here is that the great toe touches the ground only for a small part of its length. The end of the toe, even when the foot is in the plantigrade position, does not touch the ground.

The existence of the palmary transverse arch, already referred to, is also made clearer by a study of direct prints of the foot.

The skin of the sole of the foot is very tough and strong, and extremely hard to remove. Between the skin of the sole and the bones and fascia is a thick padding of fat. This is so disposed as to lessen shocks and jarring that might otherwise be keenly felt in the violent action of the foot. In the sole are no grease-forming glands, but an abundance of sweat glands. The skin of the upper part of the foot is looser and finer; so, likewise, is the skin under the arch and between the toes, permitting of free motion in the parts.

Chapter III.

THE ACTIVITIES OF THE FOOT

Having seen something of the external conformation and shape of the foot, it now becomes necessary to explain further the method of its activity, and of the phenomena manifested by the foot in action. A knowledge of the internal structure is fundamental to the further progress of our understanding of the foot.

The skeleton* forms the foundation of the fabric, giving form and solidity to the whole, and constituting the substratum to which the other parts are, as it were, applied. These bones are united together, by means so arranged as to admit of various degrees of motion between the parts. These constitute the passive means of locomotion, and their purpose is purely mechanical. The active agents in progression, as well as in the different uses required to be performed, are the muscles.

These combined means are sustained and fed by blood conveyed through arteries, and the residue, not altogether expended in the functions that are intended to be performed, and altered very considerably in its properties, is conveyed through the veins, back to the heart, preparatory to its circulation in the lungs, where it is aerated.

Fig. 14 shows the disposition and arrangement of the bones of the foot and leg. It will be noted that they are arranged in segmental character.

The foot is divisible into tarsus, metatarsus, and phalanges.

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* The bones of the foot are as follow:—Fourteen phalanges, five metatarsals, seven tarsals (astragalus, calcaneum, cuboid, scaphoid, and internal, middle, and external cuneiform bones. The bones of the leg are:—Femur, tibia, and patella.

The seven tarsals may be divided into two sets—(a) the astragalus and the calcaneum being the first, and (b) the scaphoid, cuboid, and three cuneiform bones the second.

The astragalus is connected with the calcaneum by three ligaments, situated chiefly between the bones (interosseous ligament), and unites them in a manner similar to that by which the two shells of the oyster are held together. The posterior ligament connects the posterior border of the

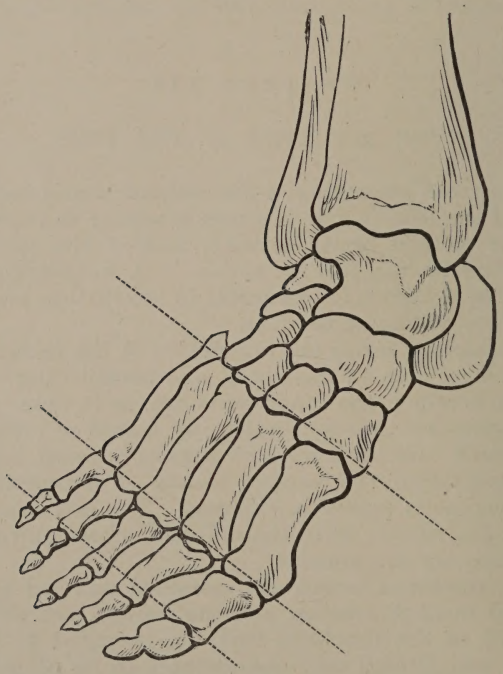

Figure 14.

astragalus with the upper surface of the calcaneum. The manner in which the astragalus is wedged in also assists in its maintenance of a proper position.

The calcaneum is attached to the scaphoid bone by two ligaments. The one on the sole passes forward and inward from the extremity of the calcaneum to the lower surface of the scaphoid bone.

The astragalus forms with the scaphoid a limited ball and socket joint. A synovial membrane lines the concave sur-

face of the scaphoid and part of the under surface of the astragalus.

The connection between the calcaneum and the cuboid is maintained by three ligaments, and a synovial membrane. One of these (the long plantar ligament) is the largest of the tarsal ligaments, extending from the lower surface of the calcaneum, and passing horizontally forwards, becomes intimately connected with the rough under-surface of the cuboid bone.

The second range of the tarsal bones—viz., the scaphoid, cuboid, and three cuneiform—are connected as follows:—The scaphoid and cuboid have their edges covered with

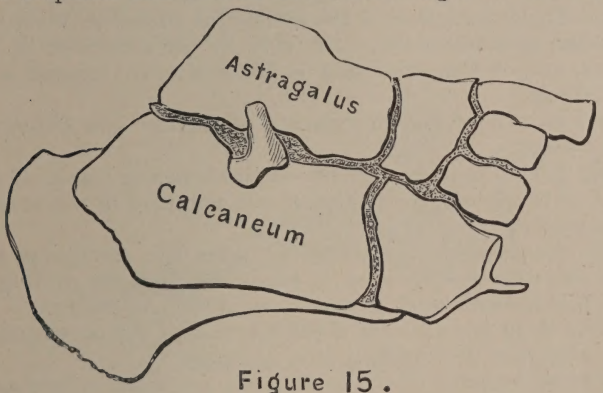

Figure 15.

Section through the foot, showing the joints 2 and 3, referred to in the text.

cartilage lined by a synovial membrane. One ligament extends obliquely between the two bones, and one is situated in the sole of the foot. The cuboid and the external cuneiform are connected by two ligaments.

The three cuneiform bones are connected by two ligaments extending transversely from side to side. The flat surfaces of the bones are lined by synovial membranes.

The three cuneiform and the cuboid articulate with the metatarsus—the first metatarsal bone with the internal cuneiform; the second is wedged between the first and third cuneiform; the third metatarsal articulates with the end of the corresponding cuneiform, and the two last with the cuboid. The surfaces of the bones where the joints are formed are lined by synovial membranes, and held in contact by upper and lower ligaments.

The five metatarsal bones are connected by ligaments.

At the hinder (or tarsal) end, two sets of ligaments are situated, consisting of three short thin bands of fibres, passing transversely across the extremities of the four last metatarsus. There is no connection between the first and second bones. At the front (or digital) end, the five bones are connected by a transverse ligament, a flat, thin band of fibres passing from the extremity of one bone to the other.

The extremities of the metatarsal bones are connected with those of the phalanges by two ligaments and a synovial membrane.

The ankle joint is formed by the highest of the tarsal bones (the astragalus) working between the bones of the leg. The upper part of the astragalus passes between two flanges, formed on the inner side by the extension of the tibia, and on the outer side by the downward expansion of the fibula.

At this joint the movements of flexion and extension take place.

By flexion is to be understood the bringing nearer of the toes to the knee; by extension, the pointing of the toes to the ground.

At the second joint—that between the astragalus and the calcaneum—provision is established for the rolling of the foot inwards and outwards—ie., from side to side.

The third joint allows of the increase of the curvature of the arch and its corresponding decrease.

The movements of the three joints are more or less associated, and are never quite independent of each other. Thus the raising of the heel, through the agency of the first joint, is accompanied by a rolling of the foot inwards by the second joint, and by an increase in the curvature of the arch by the third joint; whilst the raising of the toes is accompanied by a rolling of the foot outwards, and a straightening of the sole.

It has already been stated that these bones, and the joints made by them, are but the passive agencies of motion. The active agents are the muscles.

It is desirable now to give some account of what muscular tissue is, and of the different conditions in which it may exist.

Muscle is the fleshy part of the animal organism. Popularly, it is the "lean" of meat. It is distinguished among the tissues of the body by its power of contractility. Muscles are the instruments by which all sensible movements of the body are accomplished. Close examination shows the muscle to be built up of bundles of

bundles of fibres, and these fibres are endued with this property of contraction. The attachment of a muscle, when to a bone, may be either direct or indirect. When there is an indirect attachment, it is by means of a tendon. This tendon serves to focus the whole power of the muscle upon a particular spot, but in itself possesses none of the properties of true muscle.

Muscles vary extremely in their form. In the limbs they are of considerable length, surrounding the bones, and forming an important protection to the joints; while in the trunk they are flattened and broad, and are very often used to form the walls of the cavities which they enclose.

It is obvious that the large and powerful muscles necessary to effect locomotion could not conveniently be packed

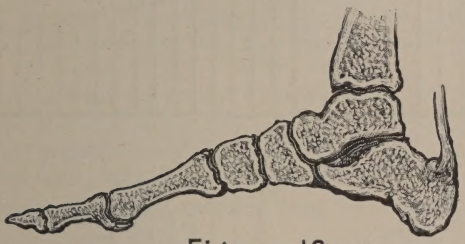

Figure .16.

Section through the foot.

into the foot. They are accordingly placed, as will be shown, in the leg, and their power conveyed by tendons passing along the upper and lower surfaces of the foot. Sometimes these tendons run in smooth grooves in the end of long bones, and sometimes as cords run round pulleys.

In the condition of rest, muscle has a slight, but very perfect, elasticity; that is to say, muscle that has been developed by action remains in this state. It thus admits of being considerably stretched, returning speedily and completely to its normal length. In the living body the muscles are always maintained in a condition of slight tension, so that they stand always, as it were, "at attention," ready at once to use (as stimulus is applied) the whole power of contraction on approximating points of attachment.

There is no doubt that, even in a condition of "rest," oxygen is abstracted from the blood and carbonic acid is given out by a muscle; for the blood becomes venous in the

transit, and thus manifests the operation of that other law, that constant and intermittent pressure causes wasting.

The contractility of muscular tissue is excited by all kinds of stimuli, but, of course, most commonly through the nervous system. If the removal of nervous influence be long continued, the power of receiving and responding to a stimulus may be lost; though, seeing this power of contractility is inherent in the muscular tissue, the lost power is due chiefly to the impaired nutrition following on long inaction. The

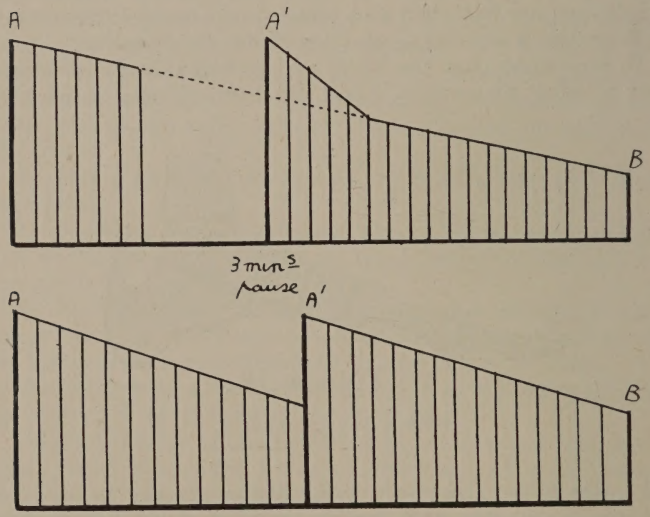

Figure 17.

maintenance of the muscle in a state of efficiency depends upon a proper supply of arterial blood.

Any form of footwear pressing upon the blood-vessels and restricting the flow of the blood current is thus seen to be injurious. A muscle also becomes rapidly exhausted from repeated stimulation; and, the more rapidly, the more quickly stimulations succeed each other. This is indicated by the diminished height of contraction in figure 17. It will be seen that the vertical lines, indicating the extent of the muscular contraction, decrease in length from left to right. The line A B drawn along the tops of these lines is termed the fatigue curve. Usually it is a straight line.

In the first diagram the effects of a short rest are shown; there is a pause of three minutes, and when the muscle is again stimulated, it contracts up to A1; but the recovery is only temporary, and the fatigue curve, after a few more contractions, becomes continuous with that before the rest.

In the second diagram is represented the effect of a stream of oxygenated blood. Here we have the marking of a sudden restoration of energy. The muscle in this case makes an entirely fresh start from A, and the new fatigue curve is parallel to, and never coincident with, the old one.*

The leading principles underlying physical education are founded on these properties of muscular tissue. Deformity may be caused by want of exercise, and as well by injurious use; and the importance of muscular action in relation to the foot itself is thus made more apparent.

It will be our purpose now to show what muscles† are implicated in effecting the movements that have been named.

The first movement is mainly effected by three muscles:

1. The muscles of the calf;
2. The posterior tibial;
3. The short fibular.

The muscles‡ of the foot itself may be classed as:

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*Fatigue curves of muscles (Ray Lankester, quoted in Kirke, 9th edition.

†The muscles of the leg and foot are —
(1) The anterior tibial (tibialis anticus).
(2) Extensor of the great toe (extensor proprius pollicis).
(3) Long extensor of the toes (extensor longus digitorum).
(4) Third peroneal, or fibular (peroneus tertius).
(5) Long peroneal (peroneus longus).
(6) Short peroneal (peroneus brevis).
(7) Triceps suræ (the calf muscle).
(8) Plantar muscle (plantaris).
(9) Long flexor of great toe (flexor longus pollicis).
(10) Long flexor of the smaller toes (flexor brevis digitorum).
(11) Posterior tibial (tibialis posticus).

‡The muscles of the foot are as follow:—
(1) Short flexor of the great toe (flexor brevis pollicis).
(2) Short flexor of the small toes (flexor brevis digitorum).
(3) Abductor of the great toe (abductor pollicis).
(4) Abductor of the little toe (abductor minimi digiti).
(5) Adductor of the great toe (adductor pollicis).
(6) Accessory flexor (flexor accessorius).

Flexors—short and long,
Extensors—short and long;
Abductors;
Adductors;
Lumbrical.

They are shown in detail in the diagrams, figures 18 and 19.

The actions of the foot upon the leg are effected mainly through the agency of three joints, to which reference has already been made, working, not singly, but in combination, viz.:

1. The ankle joint;
2. That between the astragalus and the calcaneum;
3. That between the astragalus and the calcaneum behind, and the scaphoid and cuboid in front.

The foot (in raising the heel) assumes the character of a lever of the second order, the weight being that of the body, the fulcrum being supplied by the toes, and the main power the muscles acting on the heel.

The calf muscles, whose tendon (Tendo achillis) is inserted into the calcaneum, are very powerful, and for the the task to be performed they need be. The other two muscles co-operating in this movement turn round the inner and outer ankle respectively, and are inserted, the former (posterior tibial) to the scaphoid, and the latter (peroneus tertius) to the external surface of the tarsal end of the fifth metatarsal bone. These muscles in acting raise the ankle, and, in conformity to the principle that "more than one effect results from the exercise of a function," they also support it at the sides. The first muscle (the posterior tibial), whose tendon is on the inner side of the foot, is implicated in the actions of turning the foot inwards, and the increased curving of the arch, as well as with the raising of the calcaneum, or heel-bone.

The second series of movements, the raising of the toes, the turning of the foot outwards, and the straightening of the sole, have now to be dealt with. The muscles through whose agencies these movements are effected are:

(1) The anterior tibial (tibialis anticus);
(2) The third fibular (peroneus tertius);

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(7) Lumbrical (lumbricales).
(8) Transverse muscle of the foot (transversalis pedis).
(9) Interosseous—plantar and dorsal (interossei).
(10) Short extensor of the toes (extensor brevis digitorum).

whose tendons pass, one in front of the inner ankle, and the other in front of the outer ankle, to corresponding points on the instep—i.e., to the internal cuneiform bone and the outer metatarsal.

If the skin of the foot at the sole be removed, there will first be seen a padding or cushioning of fat. Beyond this fat, a dense layer of fibrous structure, extending from the heel-bone to the heads of the metatarsus. Its middle part will be observed to spread out beneath the metatarsus, and to give off five processes which run along to the extremities of the metatarsal bones. The external portion is thick and firm; but the internal portion, which corresponds with the muscles of the great toe, is a thin membrane which appears to be prolonged from the fascia, and not to be properly an offset of the true plantar fascia at all.

Lower down, and beyond this fascia, and partly attached to it, a large muscle is to be seen, occupying the middle of the sole of the foot, being the short flexor muscle of the small toes. Along the inside of the foot is the abductor of the great toe, and along the outer side will be seen the abductor of the small toe, and, as well, the short flexor of the great toe.

Stripping these away, and going down deeper beyond these short flexors will be seen the long flexor of the great toe. Then, crossing this flexor in an oblique direction, and attached by a small muscle to the heel-bone, and dividing into four, will be seen the long flexor of the small toes. Below this second layer are third and fourth layers.

The muscles of the first layer are connected with the second phalanges of the four smaller toes, and in action they flex the second phalanges.

The muscle of the calf is attached to the heel-bone by its tendon, and has three attachments above. Its form is thick and convex behind, plane in front, and divided longitudinally at the upper extremity into two portions, or heads, of which the inner is thicker and longer than the other. Each head of the muscle arises from the upper and back part of the corresponding condyle of the femur; their fleshy fibres descend converging, and both become gradually united, so as to form a thick muscular mass. Below the middle leg, the muscular structure ends in a broad, strong tendon inserted in the lower part of the posterior extremity of the heel-bone.

There is a tendency of the thigh of the female to a cylindrical, and that of the male to a columnar, form; and this tendency to difference of shape in this and other parts

of the foot and leg establishes a need for difference in the method of pattern formation for men and women. In our investigations into pattern formation, we shall find that the method for the construction of men's patterns is needed to be different to that for women.

Just as there is a lack of straightness in the female forearm, so is there an analagous obliquity of the lower extremity. In woman, the thigh, though short, tapers ra-

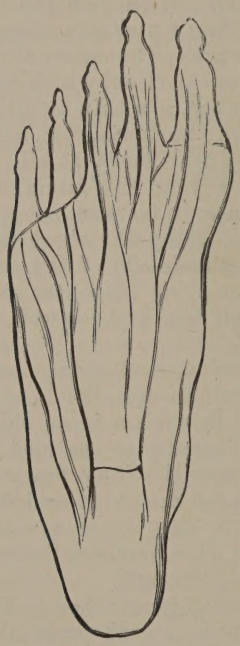

Figure. 18.

pidly, and imparts an appearance of instability to the female figure, and this effect is increased by the marked inward inclination of the thigh of woman, resulting often in an appearance of knock-knee. The inward inclination of the thigh is compensated by an outward inclination of the leg. This obliquity of the legs is the most conspicuous æsthetic defect of the feminine form in the erect posture, while it unfits them for attitudes of energy, and compels them to run by alternate semi-circular rotations of the leg.*

*Havelock Ellis, p. 51.

The extensor coming down from the front of the leg, behind the annullar ligament, divides out to the toes—one to the great toe, constituting the long extensor of the great toe, and one dividing out to the four smaller toes, constituting the long extensor of the smaller toes.

The muscles on the inner side of the sole flex and slightly abduct the great toe. The muscles on the outer side of the sole both flex and abduct the smallest toe.

This flexion is not a complete bending such as we have in the hand, but rather a pressing and holding.

When (as in the act of raising to tip-toe) the flexor tendons are tightened, they tend to draw the tips of the toes towards the point where the tendons turn below the ankle.

The muscles coming down from the front of the leg act as tractors, and at the same time

(1) Bend the knee.

Almost simultaneously

(2) The heel is raised.

At the same time

(3) The toes are pressed down,

and two long flexor muscles attached to the toes.

(4) Raise the foot to the tip-toe position,

and the impetus is gained for carrying the body forward to the next step.

In walking, one foot or other is always on the ground.

The act of leaping or jumping consists in so sudden a raising of the heel by the sharp and strong contraction of the calf muscles that the body is jerked off the ground.

Running is performed by a series of rapid low jumps with each leg alternately, so that during each complete muscular act concerned there is a moment when both feet are off the ground.

Fast walking as done in foot-races, admittedly a most strenuous proceeding, in Dr. Ellis's opinion "cannot possibly be done well, and ought not to be done at all."* When increased speed is necessary, running is the natural method.

It is also important that, whatever may be the particular form of locomotion, as much as possible a good firm pressure of the toes upon the ground should be obtained, and, in order that this may be so, it is desirable to take a limited stride.

For certain methods of placing the feet in walking, greater merit is claimed. The military position is to stand

*p. 48, Ellis, "The Human Foot."

with the feet inclined at an angle of 45deg. from each other. This position is illustrated in figure 20.

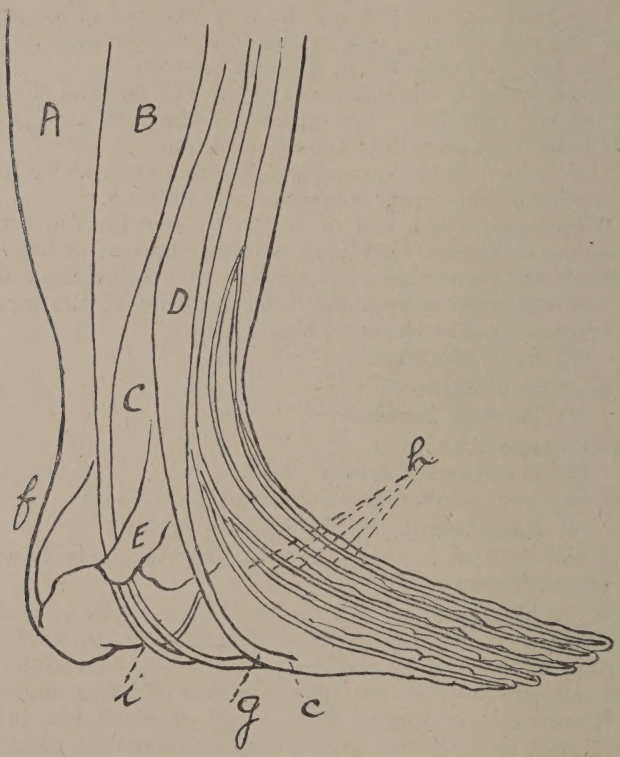

Figure 19

E, lower end of fibula, forming the outer ankle; C, the short fibular muscle, attached above to the fibula and below by its tendon, c, to the outer metatarsal bone; B, the long fibular muscle, its tendon, i, running behind the outer ankle and under the instep to the metatarsal bone of the great toe; D, the anterior or third fibular muscle, attached above to the fibula and below by its tendon, g, to the outer metatarsal bone; H, the extensor tendons of the toes; f, tendon of Achilles.

This is claimed to be a weak position for the foot; and the second position, called the "four square position," is advocated:*

* Ellis, p. 67.

First, because it is four square, and no other figure, consisting of straight lines, gives so wide a basis of support in a limited area.

Second, it is the strong position of the arch, so prone to yield in prolonged standing.

Third, a turning out of the toes tends to uplift the great toe, and so prevent the muscles acting upon it from giving so firm a pressure against the ground.

It is also claimed for the use of the foot in this position that the most complete period of rest in the intervals between steps is obtained; and, if this be so, in the light of what has been advanced with regard to the conditions

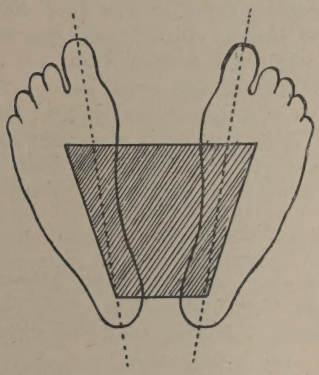

Figure 20

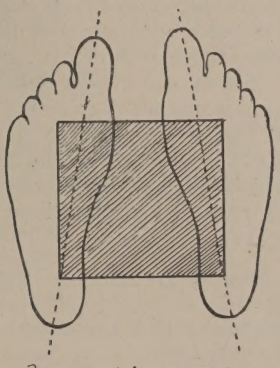

Figure 21

under which muscle works, then that is a potent fact in favour of this position.

The position of the footfalls and the method of the use of the feet have relation to the position of the leg in the use of the foot. The Red Indians are famous for great powers of endurance in walking and marching. In their method the quick walk is done with bent legs, and the entire sole of the foot is placed on the ground at once, and the feet, instead of being turned outward, are put down in a straight line. Recently, walking with bent legs and loose knees has been tried in France for military marching, with the idea that it should prove less fatiguing. The Red Indian method has been warmly commended by travellers, by Catlin, Lord Milton, and Dr. Cheadle. Ellis gives a qualified approval of the method, remarking as an objection that the feet require to be placed

in position, and finds a fatal objection to the non-straightening of the knee.

This method of walking is reminiscent of the quadrupedal position, and, wherever it is practised as a national custom, is associated with a more curved lumbar region. This distinction is also claimed to exist in European races between men and women.* The lumbar region of the column is said to be not alone longer in women than in men, but that it is moulded upon a different plan. If this be so, herein may be found a reason for the differing methods of the use of the foot which is, undoubtedly, manifested in the case of men and women.

The attainment of the upright position and the consequent development of the present form of the foot have not been without cost to the human biped, and he still bears the marks of his lowly origin thick upon him.

Yet of the two sexes, the form of the organism of the man seems most removed from the quadrupedal, and that of the woman less removed from it, with a consequent slight difference in the method of the use of the foot, of which we shall have more to say as our subject develops in its practical applications.

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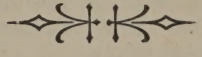
*See G. A. Dorsey, "The Lumbar Curve in some American Races"; Bull, Essex Inst., vol. 27, 1895, Salem, Mass; also "Lumbar Section of the Vertebral Column," "Journal Anat. and Phys.," October, 1888.



Chapter IV.

ON MEASUREMENTS.

Units, in scientific language, are the arbitrarily chosen standards in terms of which different quantities are expressed. In boot and shoe manufacture, the fundamental unit is that of length (the unit of mass is never used), and from that all other units are derived. That is to say, the measurements and data used in boot and shoe manufacture are derived from the English inch, and a thoroughly scientific system can be based on this unit for the home trade. The sizes (obtained by a method of division to be treated of later) are usually recorded upon a size-stick.

There appears to be no means of ascertaining when the size-stick such as we now know it was first introduced, and thence of marking the influences brought to bear in the determination of its various forms, because to trace out the growth of any tool is to express and emphasise the endeavour to meet needs that others have experienced, and often to gain the clue to the underlying principles upon which any tool should operate.

From the history of the measurement of girths, however, it may well be imagined that the size-stick was not always so far complete as it often is at this time.

At one time to "span" the foot was the accepted method for the measurement of it, and so a "three-quarter span," or a "half span," or a "span and a quarter" were statements indicative of the girth circumference at different parts of the foot. The "inch tape" has succeeded the hand span, and, perhaps, the "inch rule" succeeded the spanning of lengths as well as of girths.

The form of the size-stick as at present used admits of many variations, and, as some forms are better than others, it may be useful to enumerate them.

The simplest form is that of a rectangular piece of wood eighteen inches long, one inch wide, and usually a quarter of an inch thick, with sizes and half-sizes graduated and marked upon the plane surface. At one end is a fixed perpendicular upright, and there is another perpendicular indicator sliding along the whole length of the stick. Sometimes this slide is made with a stop, so that

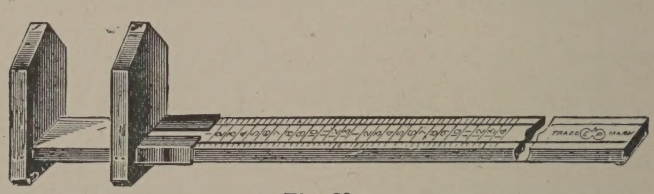


Fig. 22.

the indicator may be fixed at any desired length upon the stick.

Modifications of this form of tool are frequently met with; such as the folding size-stick, and the "jack-in-the-box" stick, which, while very useful forms of the tool, do not admit of such accurate construction as the first form referred to and illustrated in figure 22.

Fig. 23.

The essential quality in a size stick is that it should be correctly divided, and it is also necessary that the method of its construction and the material of which it is made should be such as to render the sizes marked upon the stick without variation.

It is now generally accepted that the standard from which all the other sizes should be obtained is by marking size 5 exactly at ten inches upon the stick, and obtaining the other sizes by setting off from size 5 the other sizes at a distance for each size of one-third of an inch, with, of course, one-sixth of an inch for the half-size.

This scale, however, simple as it may appear, admits of so many forms of embodiment, and these, apparently, have so much fascination for the inventor, that the principles of the size-stick have been embodied in no fewer than two hundred patents.

Figures 24 and 25 are illustrations of a stick patented by Mr. William H. Varnum, of Massachusetts.

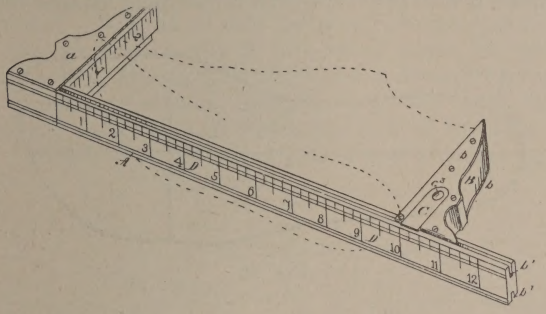


Fig. 24.

This stick consists of a moveable toe-block or index, with an improved automatic clamp, or locking device, by means

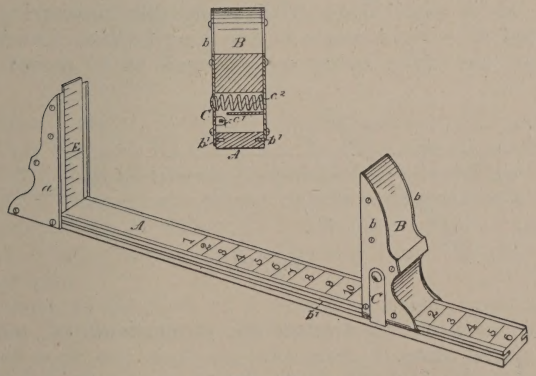


Fig. 25.

of which it may be held firmly in any desired position upon the measuring stick. The stick, in addition to being furnished with the shoe manufacturer's scale of lengths, is supplied upon its upper surface with a foot measure divided into inches and sub-divisions extending from the line or

point from which the shoe-maker's scale is estimated, which is the inner face of the heel-block upon the stick, and not from the end of the stick.

It also consists of a heel or toe block with a measure upon its inner face of inches and fractions thereof, the object being therewith to measure the spring of the last, or the elevation or height of the sole of the last at the toe. The index is also provided with a clamp or locking device.

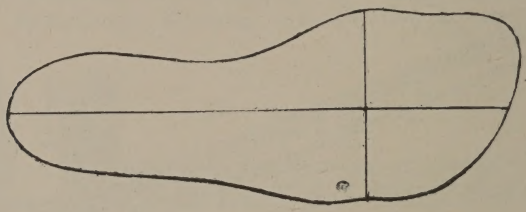


Fig. 26.

Figure 27 represents Bradley's size-stick or measuring-bar.

On the face of this bar are arranged two columns of graduations, B1 and B2. The column B1 indicates the length of the foot, and the column B2 the number of the shoe. It is also fitted with a flexible measuring tape mounted at a right angle to the longitudinal direction of the bar, the strap being so arranged as to permit it to

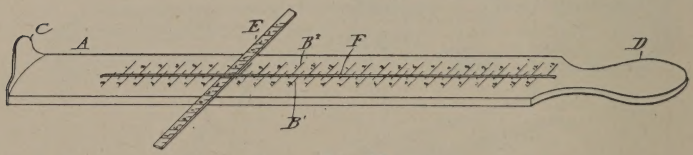


Fig. 27.

enclose the foot and disclose the circumferential measurement of the same.

Figures 28 and 29 explain the construction of the McNicol measuring bar, being a further elaboration of the size-stick.

The letter A of the drawing designates a platform, to which the measuring bar, B, is attached by a hinge at one end. When the measuring bar is thrown back, this platform may be used for marking out the outline of the

foot, or for taking a print or impression. B represents the measuring bar, to one end of which is secured the upright rest, C, against which the heel is placed in the usual manner. D is the sliding upright, adjusted to the end of the boot, and serving to show the length thereof, upon a scale marked on the bar B. Sliding in a shallow channel formed in the upper surface of the bar B is a thin slide or strip of metal, E, graduated, and provided with a cross-bar, F, at one end. Hinged to this cross-bar, on the opposite side from the graduated slip E, is a small plate, G, provided with a loop, a, through which passes a measuring tape, H. K K1 represents sliding uprights provided with slots at their lower ends, through which the ends of the cross-bar F pass. Attached to the upper end of one of these uprights,

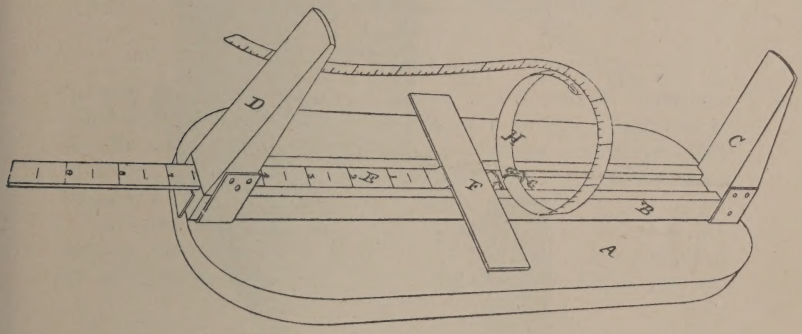


Fig. 26.

is a slip of metal, L, which extends horizontally across to the other upright, K, and serves to show the breadth of the heel, by means of the scale marked thereon. This scale L has also a vertical movement in a slot on the outer side of the upright K1, to which it is attached, in order that the height of the counter may be known from the scale upon the upright.

To measure the foot, it is placed centrally upon the bar B, with the heel against the stationary upright C, and in contact with the scale L; the slide D is adjusted to the toe, and the length of the foot noted from the bar B. The width of the heel is next taken from the scale L, and the height of the counter from the scale on the upright K1. The measurement from the heel over the instep is then noted by means of the tape H. The uprights K K1 are now removed; the scale E is drawn forward, and the necessary measurements taken of the circumference of the foot,

at suitable distances from the heel, regulated by the scale E, and made by means of the tape H.

Figures 30, 31, and 32 illustrate Cort's pocket size-stick. Figure 31 is a side view of the pocket measuring stick closed. Figure 32 is a plan of the device opened or extended for use, the toe-tongue being slid in from the end of the tape; and figure 30 is a side elevation of the same.

Figures 33-37 illustrate J. B. Sweetland's size-stick, the

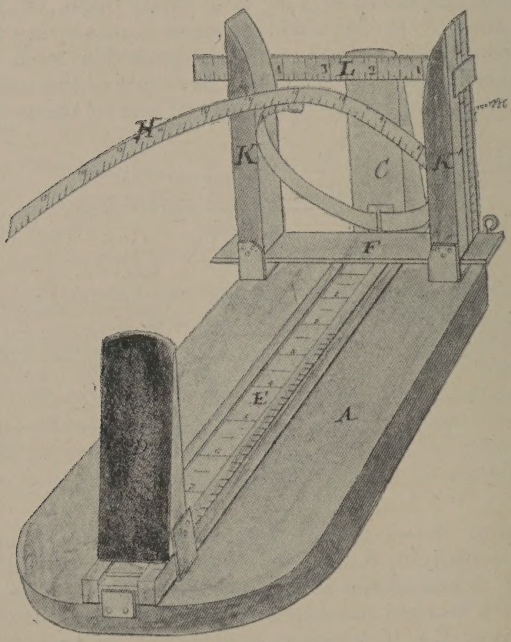


Fig. 29.

object of which is to combine in compact form several scales or measuring devices wherewith to measure the size of a shoe, the width of the ball portion, the spring of the toe, and the height of the heel.

Figure 33 is a top-plan view; figure 34 is a longitudinal vertical section; figure 35 is a transverse vertical section, taken on line 3 3, figure 37, looking towards the left; figure 36 is a vertical section taken on line 4, 4, figure 37; figure 37 shows the size-stick in side elevation.

In these drawings, A represents the case of the size-stick,

and, as made by Mr. Sweetland, this case comprises a long, substantially rectangular section composed of integral sides, a a, and ends a1 a1, cast in metal. B represents a base-plate fixed to the frame. C represents a cover-plate with a centrally dispersed slot extending from end to end. At one end of frame A is a standard D, which extends upwardly for some distance above the cover-plate C. Upon the standard D, immediately above the cover-plate C, is

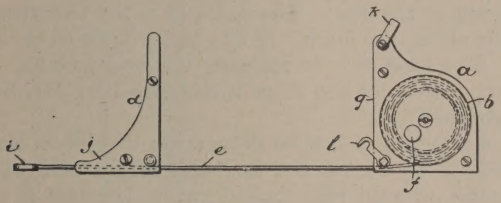


Fig. 30.

formed a scale s, and at its upper end a scale s1, comprising a series of vertical parallel lines as shown. Secured to the front edge of the standard D is a plate l, upon the face of which is formed a scale s2, similar to the scale s upon standard D.

Reciprocating in suitable guide-grooves, p1 and p2, formed respectively in partition P and a similar partition P1 is a carrier or lifter, L, moving up and down through

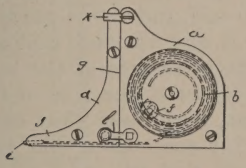


Fig. 31.

the slot C1 on the cover-plate C. The lifter L is arranged to carry a heel-rest, R.

The heel-rest R comprises the heel-shaped plate r1, which is slightly concave, as shown, and the depending shank, r, which projects from the under-side of the plate r1. The lifter L is arranged to be raised and lowered to operate the heel-rest R.

The diagrams show the mechanism for raising and lowering this lifter L. The block E is arranged to move back

and forward along the covering-plate C, operated by a screw-shaft, F.

The use of the various scales is as follows:—Scales S and s^2 are in practice substantially alike, and are intended to determine the height of the heel which may be carried by a shoe that has been made upon a last with a pre-determined spring at the toe, and also to determine whether a completed shoe has the proper height of heel to harmonise with the spring of the toe. The scale s^1 is for the recording or determination of "pitch" of the leg. Scale s^3 is the length scale. The scale s^5 is to measure the ball width.

The operation of the stick is described by Mr. Sweetland as follows:—

"In measuring a last to determine its size in length and also the spring at the toe and the height of heel which a shoe made on said last should carry, the last is placed in position with its heel resting upon the plate R and the back

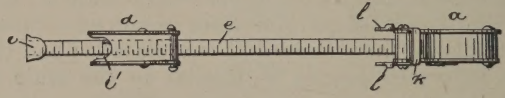


Fig. 32.

of the last resting against the plate l. The block E is now moved forward toward the toe of the last until it contacts with said toe. The lifter or carrier L is now raised by means of the shafts o o^3 and bevel-gears o^1 and o^2, thus raising the heel-rest R and the rear end of the last resting thereon until the bottom surface of the last shall be in the position which it is required the sole of the shoe made on such last shall assume, and when thus supported, the proper height of heel for such shoe can be determined by either the scale s or s^2, and the length or size of the shoe by the scale s^3, the size being indicated by the position of the lower edge of the front face of the block E, which is in contact with the toe of the last, relatively to the scale s^3. At the same time, the scale s^4 upon the face of the block E will indicate the spring or upward inclination of the toe portion of the last. In determining the width of the last across the ball portion, the last is placed with its ball portion resting upon the cover-plate C, one side of the last contacting with the top forward edge of the lifter or carrier L, the front line of which should be substantially in line with the right-hand end of scale s^5; and the block E may then be rapidly moved forward by depressing the lever

g2, as described, and brought into contact with the other side of the last at the ball portion, whereupon the width

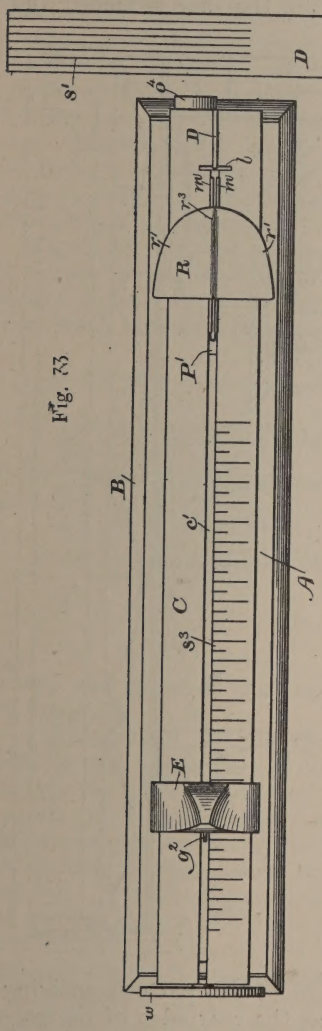


Fig. 33.

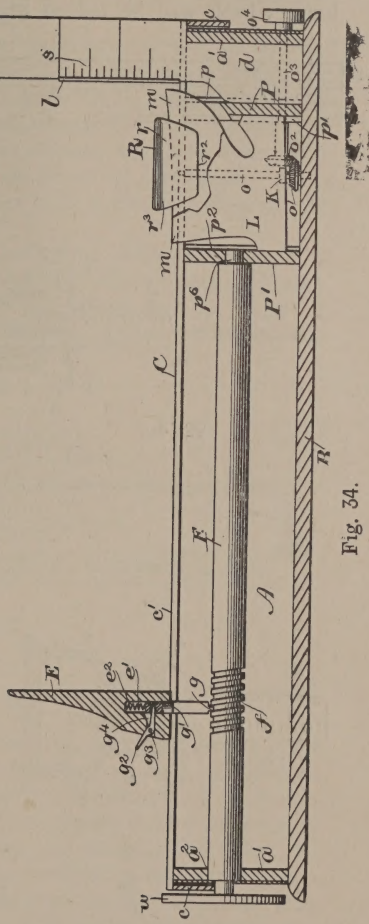


Fig. 34.

at the ball portion may be accurately determined. In measuring a shoe-pattern, the lower edges of the pattern are brought together and the heel-rest R is removed from

the lifter L. The edges of the pattern at the heel portion are now inserted between the members m of the lifter L to an extent equalling the material at the bottom of the pattern, which will be lasted in when the shoe is made; the

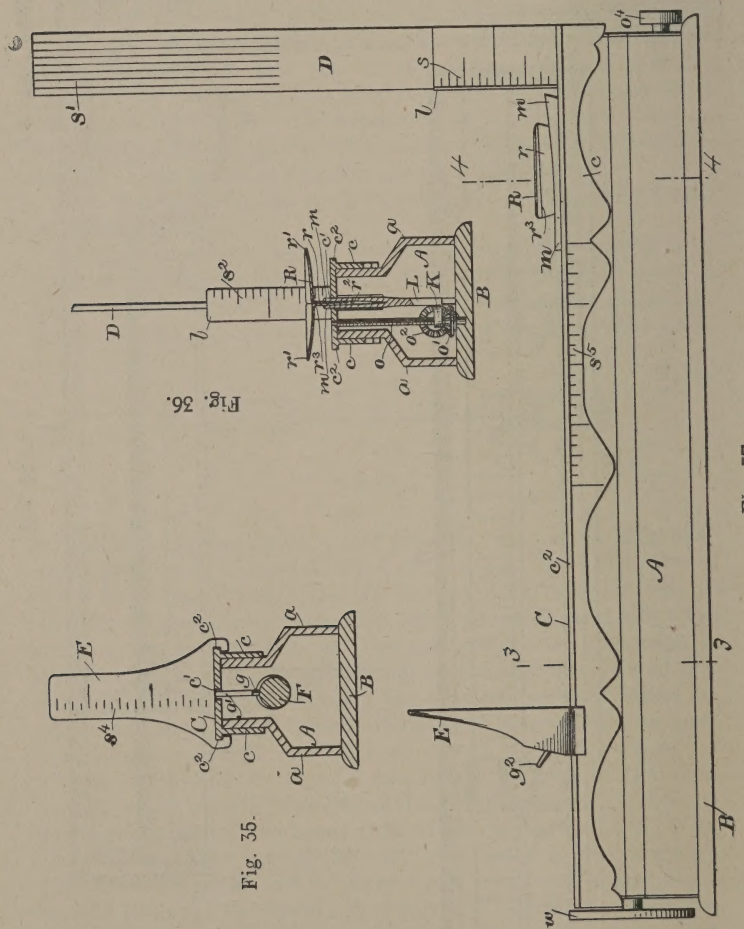


Fig. 37.

Fig. 36.

Fig. 35.

bottom edge at the forward end of the pattern entering the slot c1 for an equal distance, the rear edge of the pattern at the heel portions being in contact with the plate 1. When in this position, the top portion of the pattern will rest against the side of the standard L and upon the

scale s1 on said standard, and such scale will indicate the rake of the upper of the shoe made from said pattern with a heel of the height determined by the relative position of the pattern to the scale s or s2."

Figures 38 to 42 explain an apparatus invented by Mr. Havard F. Goodrich, and patented November, 1904, by means of which apparatus it is possible to accurately register the positions on the horizontal and vertical planes that any measurement of the foot is taken; and also renders it possible to reproduce these positions on the lasts. It is possible, also, by this device to plot a front profile of the foot or last so measured.

Figure 38 is a plan of the measuring device; figure 39 is a side elevation, showing the parts in one position of use; figure 40 is a central longitudinal cross section, showing the parts in other positions of use; figure 41 is an end

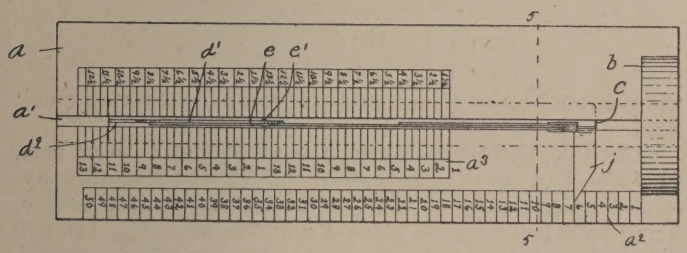


Fig. 38.

view; and figure 42 is a cross-sectional view of the line 55 of figure 38.

The usual flat base, a, is provided with a vertical heel post or rest, b, secured at one end thereof and adapted to engage the back of the heel, as in all devices of this character. A T-shaped groove, a1, is formed in the upper side of the base a, and extends from one end to the other, in the middle thereof, and a bar, c, is slidably mounted in the groove. A scale-plate, d, is secured to the opposite end of the bar c from the heel-rest, this plate being held perpendicularly to the surface of the base a, and extending through the narrow middle portion of the groove a1.

A pointer arm, j, is secured to the opposite end of the bar c from the scale-plate d, this arm j extending through the groove a1, and lying parallel with and close to the surface of the base in position to register with a scale, a2, on the base, which is divided into equal spaces, generally

of one-eighth and one-fourth of an inch in length, numbered in regular order, and extending from the face of the heel post through the entire length of the base-piece. The middle portion of the base is graduated with size-scale graduated (scale a^3), by which the length of the foot or last may be measured. A slot, b^1, in the heel-rest permits

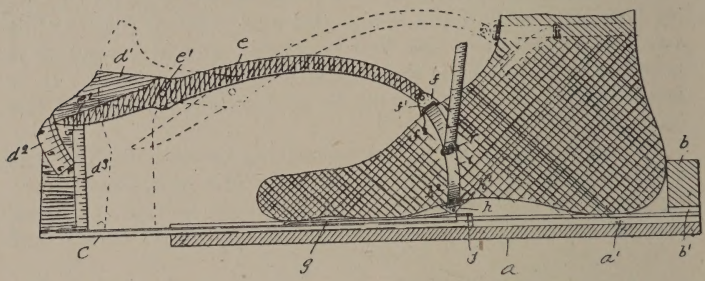


Fig. 39.

the pointer j to be moved past the rest in measuring small sizes.

A flexible, sheet-metal, arm, e, is pivoted at e^1 to an arm, d^1, formed integral with plate d. Both of these arms extend longitudinally of the bar c and the pivoted arm e, being held between the plate d and the heel-rest. It will also be noted that the arm e has a pointer e^2 at one end,

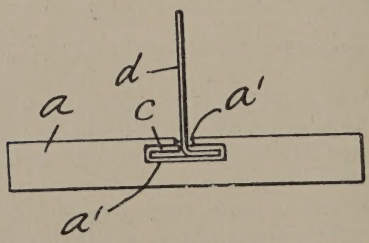


Fig. 40.

so placed as to move into register with the graduations of an arc-shaped scale, d^2, on the scale plate d, having pivot e^1 as its centre. A tape-clip, f, is pivoted to the end of the arm e, next the heel-rest; f^1 is the tape aperture of this clip, and f^2 is a foot engaging face. The length of the clip-bearing portion of the arm e is such that the pivot of this clip is in close proximity to a vertical plane extend-

ing longitudinally of the pointer j through its longer edge, while the pointer e^2 is in register with a part of scale d^2.

A spring wire, g, is connected at one end to the measuring bar c, and extends longitudinally thereof in the slot a^1 towards the heel-rest, and a tape clip, h, is pivoted to its opposite end, this clip having a flat foot-engaging surface, h^2, and a tape aperture, h1, and is so arranged that its pivot is approximately in the vertical plane of the longer edge of pointer j.

The manner of using Goodrich's machine is as follows: — The person taking the measurements is provided with a card conveniently ruled for the special purpose. The foot or last is then placed on the base-piece with the back of the heel against the heel-rest b, and the bar c is moved toward the heel-rest until the adjacent edge of the scale-plate d engages the end of the toe, said edge thus register-

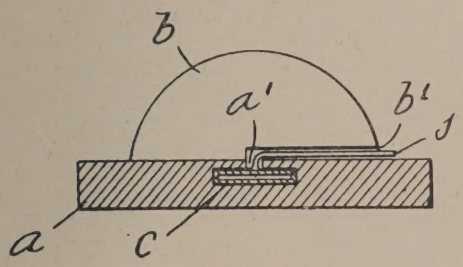


Fig. 41.

ing the size on scale a^3. The flexibility of the arm e enables it to be bent to one side while making the length measurement. A tape, i, is then passed through the clip f of the arm e and the clip h of the spring-wire g, and the foot is measured while the tape is thus held in as many positions as desired between the instep and the end of the foot, the tape being drawn closely about the foot, so that the face f^2 of clip f will be pressed against the middle of the front of the foot, and the face h^2 of clip h against the middle of the bottom thereof, the arm e swinging on its pivot and the wire g bending, if necessary, to permit such movement, as shown in figure 39. In order that the tape may be moved to take a measurement, the bar e must be moved therewith, so that the pointer j will register on the scale a^2 the spaces which the tape is from the heel-rest, or its horizontal position with relation thereto, and the pointer e^2 will register on the scale d^2 the distance in

inches from the face of clip f to the surface of base a1—that is, the height of the foot at the point at which the measurement is taken.

The tape measurements and the corresponding readings on the scales a2 and d2 are all tabulated together. Preferably the tape i is secured to the clip h at a predetermined point, so that the measurement from the clip h to the usual rin r in one end of the tape is an even number of inches, the even graduations on the tape beginning at the clip h and extending toward the opposite end thereof as far as necessary. In case there should be any special deformity in the foot, the measurement may be taken separately from the middle of the bottom of the foot to the middle of the

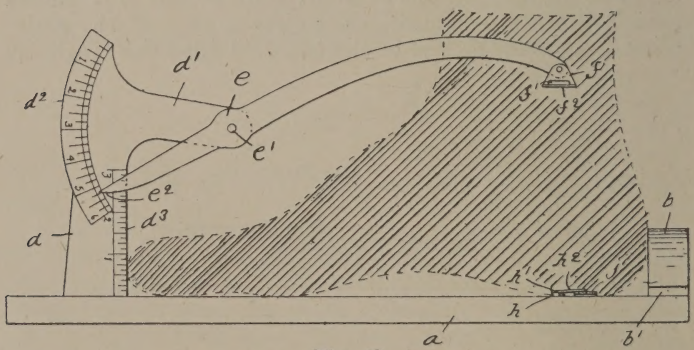


Fig. 42.

front of the foot at each side thereof—that is, the measurements may be taken separately, over each side of the foot from the clip h, which is always held in the groove a1 at the middle of the bottom of the foot to the clip f, which is held against the middle of the front of the foot. These particular measurements will then be recorded with the position measurements, as before described. In case a person wishes a boot of a certain height, the arm e is swung so that its pointer e2 registers this height on the scale d2, and then the measurement about the ankle or leg is made, as illustrated in dotted lines in figure 42, and then the succeeding measurements down to the instep may be made in like manner, the heights at which these measurements are made being registered on the scale d2 and recorded with the tape measurements.

As has already been indicated, this apparatus may also be used for pattern-cutting. The particular method for

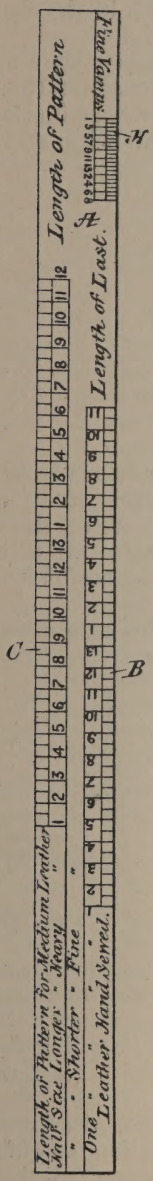

Length of Pattern
Fine Vamps
Length of Last.
Length of Pattern for Medium Leather
Half Size Longer " Heavy "
" " Shorter " Fine "
One " Leather Hand Sewed.
A
B
C
H

Fig. 43.

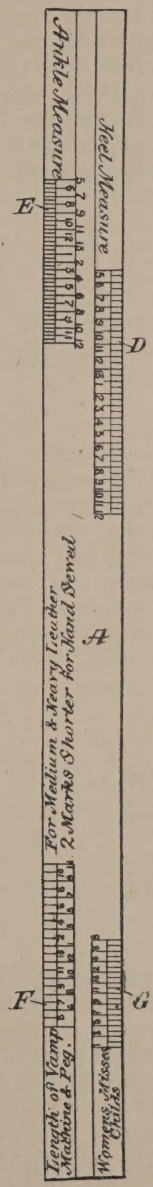

Ankle Measure
Heel Measure
For Medium & Heavy Leather
2 Marks Shorter for Hand Sewed
Length of Vamp
Machine & Peg.
Womens Misses
Childs
A
D
E
F
G

Fig. 44.

its use in this connection will be dealt with in the chapter on pattern design.

One further simple modification of the size-stick remains to be noticed, after which a few leading adaptations of scales, having for their object the ready determination of sizes and fittings for retailers, will be dealt with, and will close this important section.

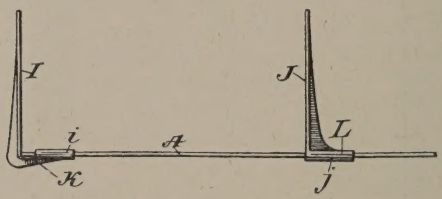


Fig. 45.

The figures 43 to 47 represent an attempt made by Mr. Damer, of Toronto, to provide a combination rule for the use of shoemakers; first, that should embrace all the measurements and sizes necessary in the manufacture of boots and shoes, and, second, that should also be useful both as a bench-rule and size-stick.

Figure 43 represents one side of Damer's rule drawn to

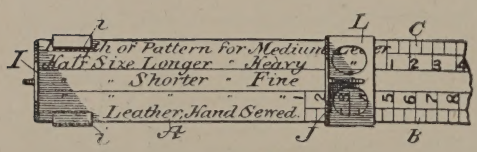


Fig. 46.

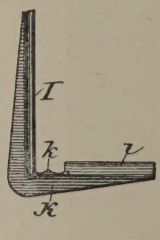


Fig. 47.

scale; figure 44 the reverse side of same; figure 45, a side elevation of a portion of the improved rule, when used as a size-stick, being fitted with detachable brackets for that purpose; figure 46 is a plan view of the foregoing figure; and figure 47 is a detail drawing of the end bracket drawn to full size and part broken off.

The rule A is formed of any suitable metal or wood in the shape of a flat strip, rectangular in section, and of sufficient width to have the different scales marked thereon.

It is generally made eighteen inches long, with the scales arrranged as shown in the drawings on both sides.

The scale B (marked as "length of last") is the ordinary third of an inch division of sizes, and, of course, it is the one upon which all the others are based and regulated.

The scale C (marked "length of pattern") indicates the length the upper should be to fit the foot indicated on scale B, and to include lasting allowance and seams. It is designed by increasing each sub-division, or unit, of scale B, : by 1-42nd of an inch. That is to say, each unit of scale C is 1-42nd of an inch wider than the units of scale B. It will also be noted that scale C starts $1\frac{1}{4}$ inches more forward than scale B. Obviously, the fact of varying substances and methods of manufacture have an effect upon the amount of this allowance, so the scale is provided with instructions to meet these variations.

Scale D is for the determination of the heel measure, and on this particular scale is recorded child's size 5 as four inches, and the adult size 5 is six and a-half inches, the size here, as in all others, in creasing or decreasing with the length measured on scale C, or the length of the pattern.

Scale E, below scale D, is marked "ankle measure." It is a scale of one-eighth grade. The children's size 5 is two and seven-tenths inches from the end of rule.

Scale F, marked "length of vamp, machine, and peg," is the scale on which the length of vamp or that part of the pattern corresponding thereto is marked to indicate the length of the pattern, the size of the finished shoe and the last. It is a scale of one-eighth grade, the children's size 4 being marked hereon as two and four-tenths inches, and the 12 adult size five inches from the initial point of measurement.

Scales G, F, and H practically explain themselves.

In figures 45 and 46 are shown detachable end and sliding brackets, I and J, respectively, applied to this rule and adapting it for use as a size-stick for measuring the length of the foot. The end bracket I is formed as shown, and is essentially a standard or an arm at right angles to the rule A.

During the last three years, several notable efforts have been made, in recognition of the fact that boot retailing is the ultimate of boot manufacturing, to codify and simplify the methods of distributions by means of different pieces of apparatus about to be noticed. The underlying idea of all these inventions is that there should be a ready

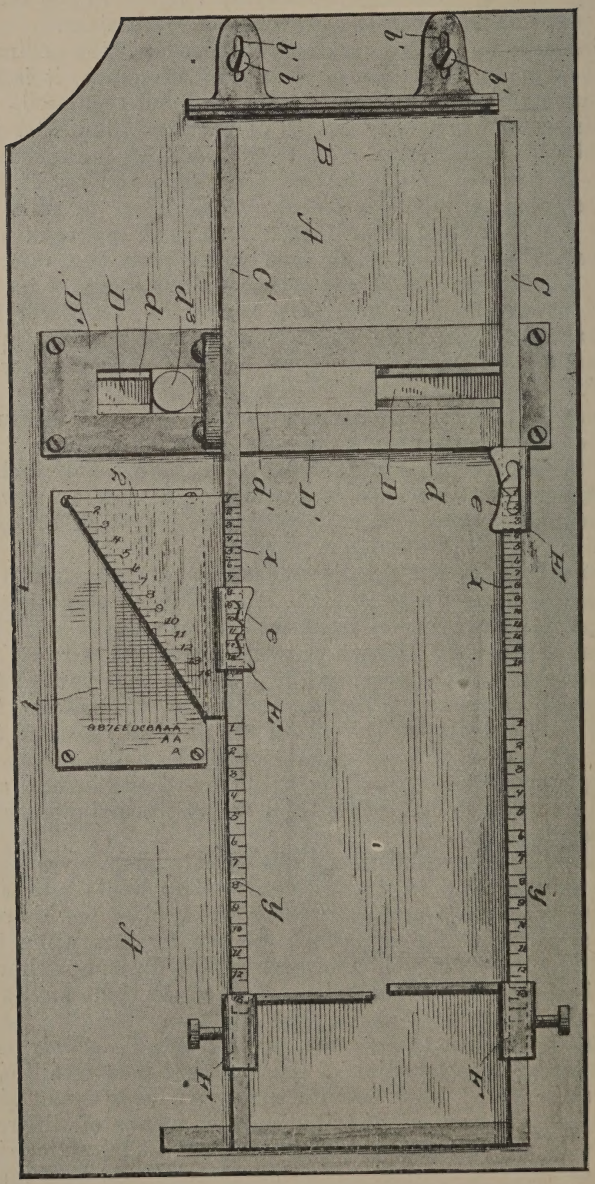


Fig. 48.

means available for the use of the retailer to determine not alone the length-size, but the fitting also, that any foot needs. Several English manufacturers have adopted these appliances, and lease them, in connection with the sale of their manufactures, at a rent to the retailer.

I propose now to notice three or four of the devices used in this connection in the order of their production and development.

Figs. 48-51 and 54-56 represent Hertzler and Smith's foot-measuring device, and has for its object the provision of size-indicating devices "to expedite the fitting," and means for "readily determining the correct length and width of shoe for both right and left feet and in all cases."

Referring then to the accompanying drawings, the letter A designates a platform or base of general rectangular form and made of suitable materials. This base has at the rear an upwardly projecting heel-rest B, longitudinally adjustable by means of screws. At each end of base A are longitudinal bars C and C^1, one bar, C, being fixed and extending the full length of the base, while the other bar, C^1 is so arranged as to have a lateral movement, to accommodate feet of differing width. For this purpose a transverse recess D is formed in the base plate, into which is inset a transverse metal piece D^1, having formed therein a lengthwise slot d. The bar C is fastened to this piece D^1; at one end thereof. and working in a slot d is a slide d^1 fastened to the bar C^1, and acted upon by a coil spring d^2, fixed to the under-side of metal-piece D^1 to force it inwardly upon the base-plate towards bar C, a set-screw d^3 being arranged to fix the adjustment of bar C^1.

Upon the upper surfaces of the bars C and C^1, at the central portion thereof, is the size-scale x, with sub-divisions for half-numbers. An indicating-slide E upon each bar has a concave inner surface e to receive the ball of the foot, is open at the top to expose the scale below, and gives the correct length or size of the shoe by shoe-numbers.

At the forward end portion of the bars C C^1, upon the inner surface thereof, is marked the toe-scale y from "1" to "13," inclusive, with sub-divisions for half-numbers, and correctly estimating in connection with indicating-slide F, having set-screws upon each said bar, the length or size of the foot by shoe-numbers, which will ordinarily agree with the size given by the scale x, but in any case in feet of unusual formation will give the proper length of the shoe.

It now remains to find the width of the shoe, and for this purpose there is provided a width-scale Z, of diagonal or

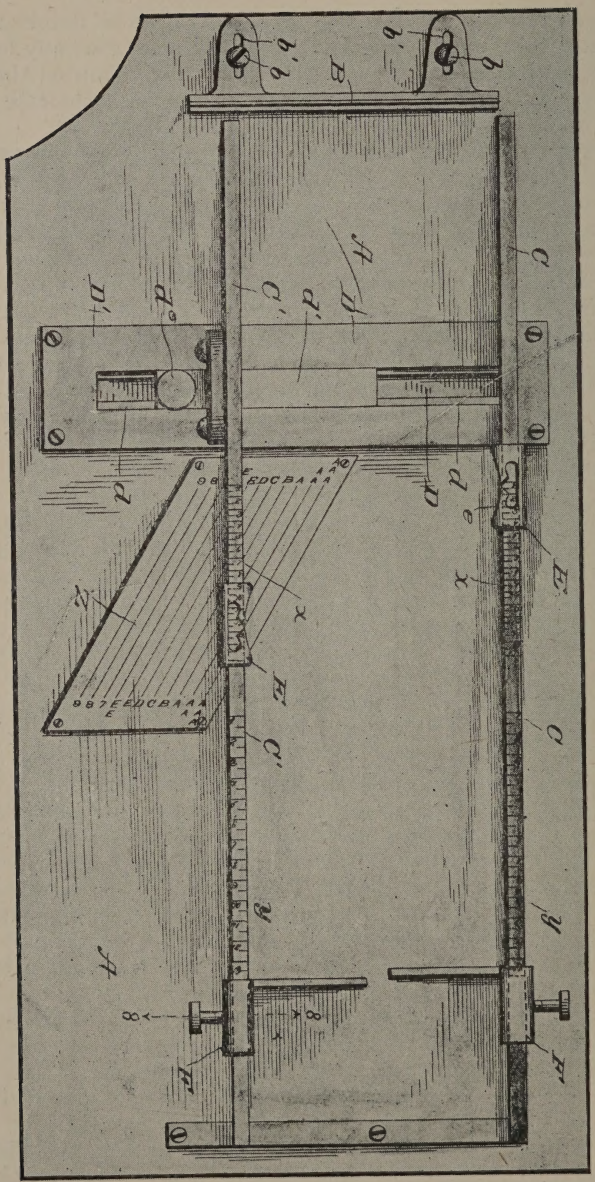


Fig. 49.

oblique lines or divisions intersecting the size-scale x upon movable bar C1, said oblique lines being marked 9, 8, 7, EE, E, D, C, B, A, AA, and AAA. When the adjustment of bar C1, which works over scale Z, is fixed, or when this bar rests against the side of the foot, the opposite side being against bar C, the correct width will be indicated by the intersection of the division or sub-division, marking the size in the scale x, with one of the divisions of the width-scale Z.

In figure 49 of the drawings is shown a modified form of the invention, wherein the width-scale is represented by longitudinal lines or divisions 1, parallel to the sides of the base-plate, and which act in connection with triangular plate 2, carried by the movable bar C1, and bearing the divisions of the size-scale x to estimate the width of the shoe. In calculating the size or length of the foot by the size and toe scales x and y, the bars C and C1 and their slides are used separately for the right and left foot—that is to say, but one ball-slide and one toe-slide for each foot.

A machine worked on much the same principles as the "Hertzler and Smith," but much simpler in design, is the "Goodbar Foot Measuring Device" (patented October 24, 1905). The object of this machine, as of that previously described, "is to enable shoe dealers to readily and accurately measure the foot, . . . and to determine the size of the shoe corresponding thereto."

By reason of the substantially constant relation existing between the length of the foot, and the distance from the heel, to a line extending transversely through the ball of the foot, and by reason of the approximately uniform increase of width in proportion to the length of the foot, it is claimed that a scale based upon the constancy of these relationships may be devised which for any given length of foot shall indicate what the width shall be; or, given the width at the ball, what the length shall be.

Of course, within certain limitations, and for the use to which the apparatus is to be applied, this is correct.

A scale which for any width shall indicate the corresponding length may, therefore, be so constructed as to make the results of markings indicated thereby referable to any two available co-ordinate axes, a method well understood in applied mathematics.

In the Goodbar Device, such a scale is used, and applying thereto a pointer or index the position of which is determined by the position of the ball of the foot being measured; the width

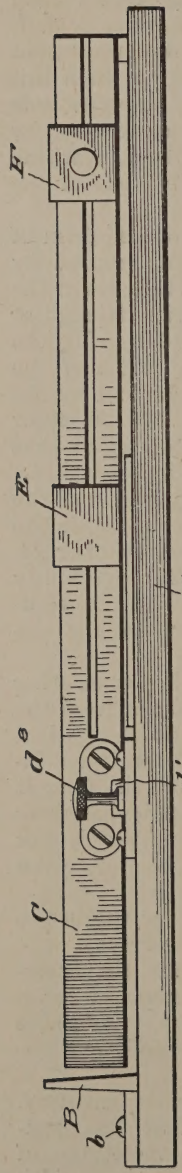


Fig. 50.

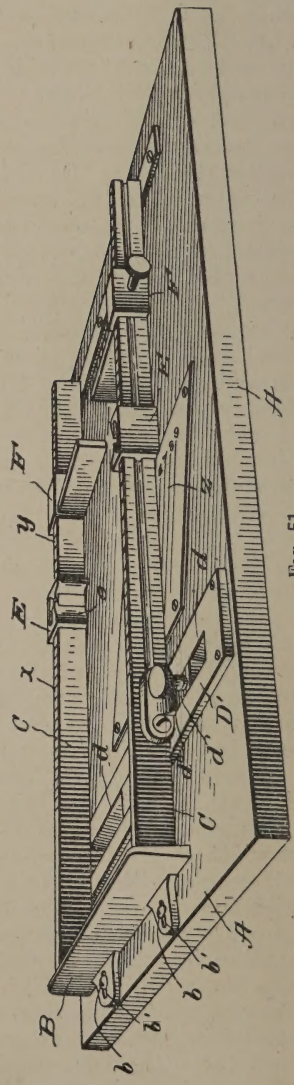


Fig. 51.

of the foot being ascertainable by the pointer as applied to that part of the foot. The simple and capable manner in which these principles are embodied may be seen by a reference to the detailed description of the invention.

Figure 52 represents the base plate provided with a chambered or depressed portion 2, and 3 a cover serving as a platform for the direct support of the foot F. One of the lateral vertical walls of the chamber 2 is shallower than the opposite one, thereby leaving a longitudinal slot 4 for the free passage of the travelling arm carrying the pointer, as will be shown.

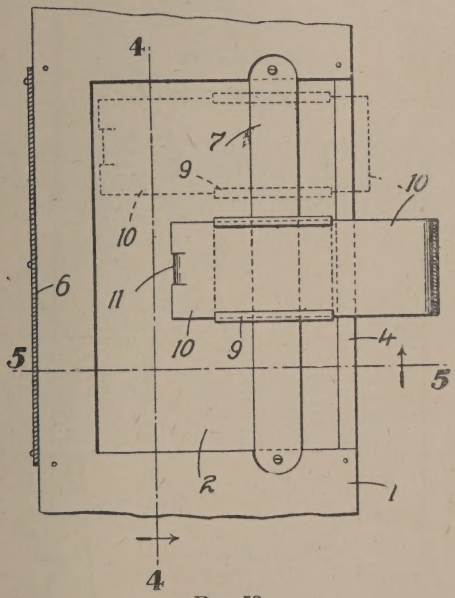


Fig. 52.

The rear end of the plate 1 is provided with a heel abutment 5, and the side opposite the slot 4 is provided with a lateral wall 6 for the side of the foot to press against. Disposed within the chamber 2, and longitudinally with the plate 1, and mounted slightly above the bottom of the said chamber 2, is a bar or rail 7, along which is mounted a runner or plate 8 adapted to reciprocate along the same. This runner is provided with lateral grooves or ways 9 for the reciprocation of the arm 10, terminating in a curved wing 12 for engaging the ball of the foot. This arm has

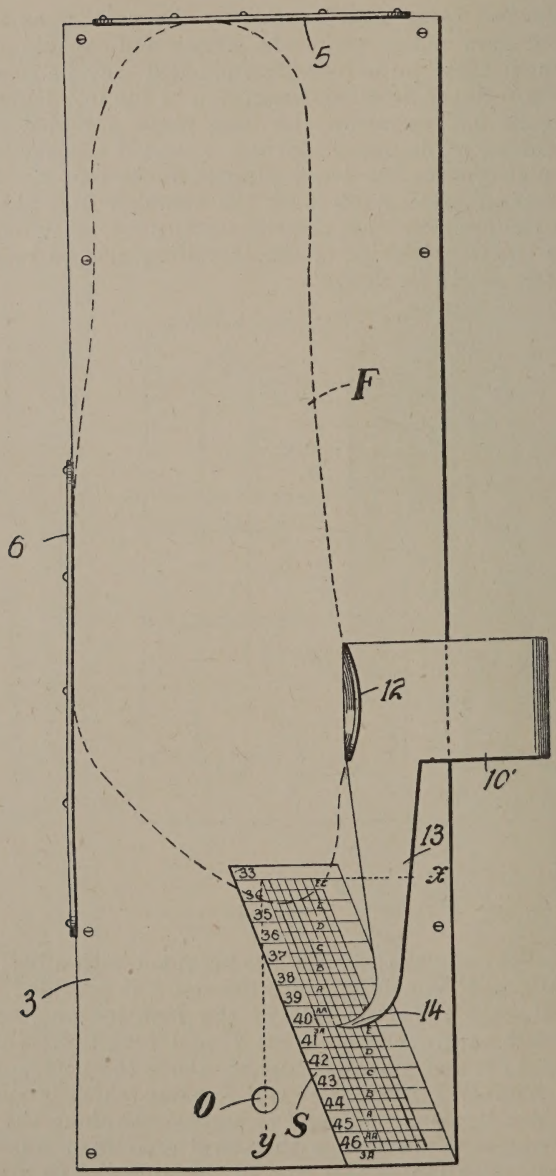


Fig. 53.

a lateral extension 13, as shown in the figure terminating in a pointer or index 14, which co-operates with the scale S stamped upon the platform.*

The scale itself is composed of a series of lines disposed parallel to the axis x, and spaced suitably apart in the direction of the axis y.

Intersecting the first set of parallel lines is a set of parallel oblique lines marked to indicate (3A, A A, A, B K) the width for any particular length.

Now, since the width of a foot increases with the length, progressively, the designation of the width for one length

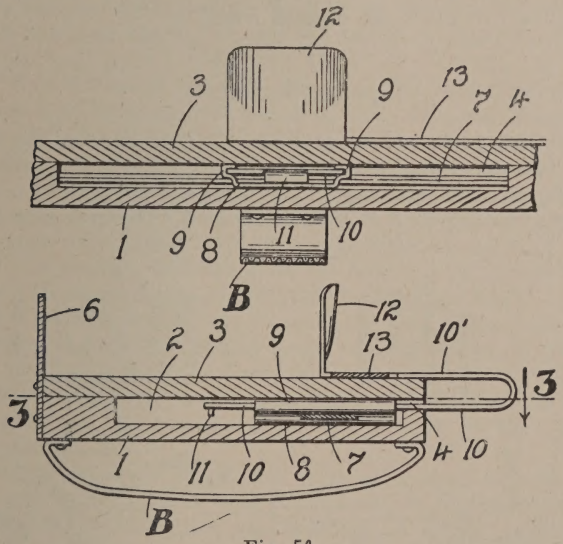


Fig. 54.

will suffice for designating the width for any other length, and, since the widths are measured along lines parallel to the axis of x, and at the same time bear a constant relation to the lengths, it follows that the width lines will be disposed at an oblique angle to the respective co-ordinate axes, the angle of obliquity fixed by actual experience.†

* As stated before, the scale is referrable to two co-ordinate axes, x and y; the former being the axis of abscissa and the latter the axis of ordinates.

† The scale shown in the drawing is marked in an arbitrary manner; of course, actual inches or sizes can be indicated. As the in-

In the actual fitting of shoes, the customer places the foot upon platform 3, with the heel well against its abutment 5, and the side of the foot close to the wall 6. The assistant carefully adjusts the wing 12 of the index to the

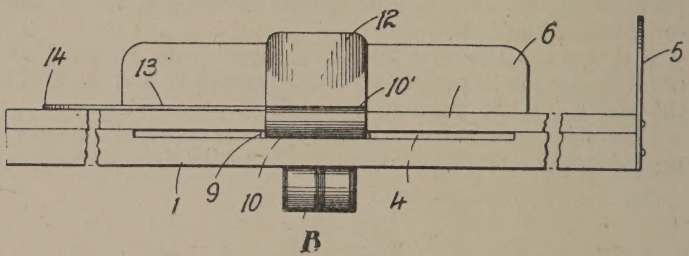


Fig. 55.

ball of the foot, and notes the reading on the scale to which the index points. In the illustration the index points to a length corresponding to the numeral 40, and to a width corresponding to A. For the length corresponding to 46,

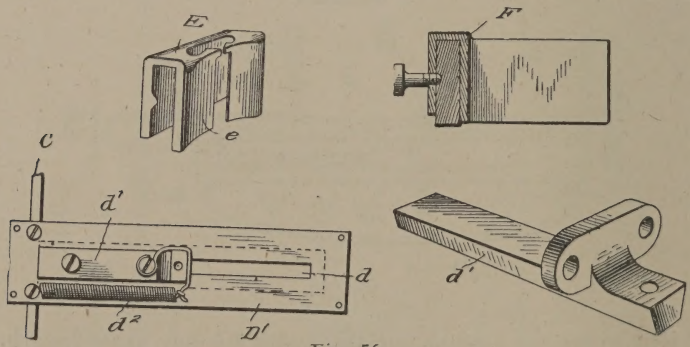


Fig. 56.

the width A would be correspondingly greater. For a like reason, 33 EE would correspond approximately to a 37 B in the width, but not in the length.

Of course, this is essentially an American method of fitting, in which small regard is had to increased length. If the foot is extra wide, the shoe, therefore, would be extra

strument is for use in a retail shop, it is argued that it is not always best for the customer to know the markings.

long. Seeing, however, how much the American practice is influencing the English trade, the method may be found acceptable—indeed, has already found acceptance with the English public, and, therefore, the results yielded by the machine on the determination of size and fitting may not be said to be antagonistic to the English methods.

Similar objects are sought to be served by the use of "Halbach's Fitters." These have had a considerable vogue in the English trade in connection with a line of branded boots for men's wear. Briefly, they are counterparts, so far as the sole form is concerned, of the lasts to the number and fitting of which they correspond, one fitter for each size and fitting. They are shown in the following figure 57.

The denomination used on the English standard size-stick has now to be considered in relation to girth denomination, and also to the standards used in other countries.

Various attempts have from time to time been made to improve the denomination used upon the English size-stick; and most of these attempts at improvement are based upon the supposition that, whilst one-third of an inch is too great a difference to be made, one-sixth is too small a difference between size and size for the length.

Now it will be well for us to grasp all that is involved in these various attempts at the improvement of the denomination, or fraction of the inch, to be used in the arrangement for lengths, and to state to ourselves as clearly as we can exactly all the conditions of the problem as they are discoverable to us.

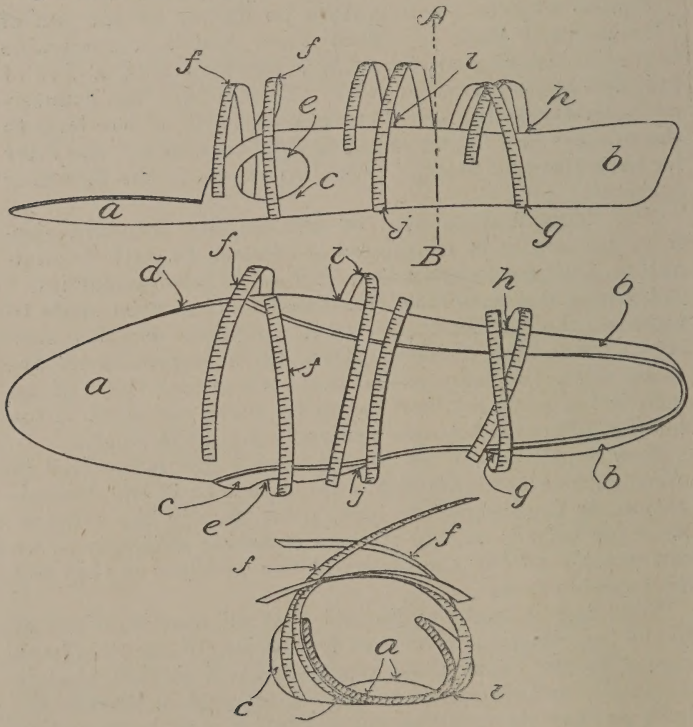
Now, first it ought to be said that all considerations as to the best fraction to be used for the length ought to have regard to the harmonious arrangement of girths; that it ought also to have regard to systems adopted in other countries, so that the result of any alteration may be to render the final system as international as possible.

Now, let it be further noted that, whilst under the existing system the fraction used for increase between size and size for length is one-third of an inch, the fraction used for the increase of girth measurements is usually one-quarter of an inch for the whole size, and one-eighth for the half-size.

To so progress with girth measurements by the addition of a quarter of an inch is, admittedly (on a complete range of sizes) to use too large a unit; and, under this method, a "skip" in the tables is necessitated. That is to say, in some part of the series two sizes are of identical girth

circumference. It is not, however, to be understood that, even though this be so, the resulting lasts would have no difference in the fitting.

Assuming a man's last size 8 with a nine-inch joint; a last length 8½ with the same joint measure would fit a larger foot than size 8. The mere addition to the length



Halbach's Fitters

Fig. 57.

establishes a difference in the fitting of the circumference, brought about by the new relation existing between the various corresponding points of the last or shoe and the foot. In short, it is the difference that may be made in the "fitting" of two sizes of identical length and girth, one having a longer fore-part than the other. There is always a difference in fitting made by "form" or "shape,"

and upon this point more has to be said when the subject of lasts has to be discussed.

It is sometimes sought to get over the difficulty associated with the arrangement of the differences for girths by making a table of irregular gradations, and these methods usually assume that the difficulty can be conquered by the application of reasoning something like this:

Assuming a quarter of an inch is anything like a correct addition between size and size for girths of adult work, then, children's and infants' work being so much shorter in length, it is incorrect to establish an equal difference in the girths of the smaller lengths. A line ten inches long to which one inch is added is not treated proportionally to it, if to a line five inches long the same amount of one inch is added. That is correct reasoning enough. It is to be noted, however, that writers and manufacturers who argue for a larger differentiation in the measurements of the child and the adult tables do so simply with regard to girth dimensions, and never so with regard to the length. One has readily to admit the need for this differentiation, but it must be made on a proper basis, taking into full consideration more series of facts than one.

In arguments of this sort the mistake is too often made of regarding the infant foot as an ideal and uncorrupted form of the adult foot. Uncorrupted, in the majority of cases, it undoubtedly is; but it by no means follows from this that it is the ideal form of an adult foot. One might just as well argue that the infant is the perfect form of the man; or, in regard to feet, that the fœtal foot was the perfect form of the developed foot. Development has to ensue upon generation, tissues have to ossify, and parts which in the infant are more or less cartilaginous "shadows" of the bones of the adult foot are, by the deposition of calcareous salts during the process of growth, made thus into actual bones.

Now, just as there is not an even rate of growth from infancy to adulthood, so neither is the growth rate of the foot itself proportional. If an infant progressed in its weight addition at the same rate for its whole life as at the first weeks of it, at the adult stage the weight would be four tons. We may know from this that at least there is not a flat rate of progress in weight addition. Speaking generally, the period of greatest increase in stature is in the first year of life, the growth of the second year being half that of the first year, and gradually declining until about the twelfth year of life, when the rate is about one-fifth that of the first year.

So with the foot itself the growth rate in length is more rapid than the growth rate of circumference, and it is only upon a full review of these facts that all reasoning regarding the arrangement of lasts for all the series of feet must be based. Those who grade infants' work, for instance, down from adult sizes are plainly in error.

Taking the well-known tables of Mr. Alden, of Norwich, we find the rule stating that the seat is three-fourths of the forepart is sustained in the case of the adult figures; but that the infants' dimensions graded from them by regular gradations of thirty-seconds of an inch are altogether wrong.

Thus, the figures given for a woman's size 5 are: Forepart, $2\frac{3}{4}$ of an inch, heel, 2 5-32 of an inch; or equivalent to sixty-nine eighty-eighths of an inch (69-88), giving a heel with equal to three-fourths of the tread within three eighty-eighths of an inch (3-88).

The figures given for infants' size 4 are: Forepart, 1 14-16 of an inch; heel, 1 16-32 of an inch—a like proportion; whereas in experience it is found that, whilst these parts have the most constant proportions of any existing between the parts of the foot, yet that even here these relations are not maintained below size 8 at any rate, and that, certainly, these proportions are not true of 4's to 6's, and still less true of the earlier sizes.

The greatest difference in the proportions and relative dimensions of the feet appears to be in the length of the toes,* and hence of the length of the forepart of the last.

These reasons help to make it clear that the problem involves much more than the adherence to a strict proportionate rate of increase between girths and lengths. If also it be understood that the rapidity of the growth rate has a practical influence upon the gradings (simply the child would "grow out" of exactly graded work), then progress in the understanding of the problem is possible.

Where a system of irregular gradation of girth measurement is adopted, the differences made are as follow: —

A difference of one-eighth of an inch between the girths of each size, 6 to 9.

A difference of three-sixteenths of an inch between the girths of each size, 10 to 13.

---

* The length of the fifth toe of a child one year old being three-eighths of an inch, at seven years is five-eighths; whilst the great toe (to centre of ball) aged one, being six-eighths, at aged seven was one and seven-eighths.

A difference of one-fourth of an inch between the girths of each size, 1 to woman's.

It is admitted, however, that it is desirable to have a method of last-scaling that will allow of an even progression of these additions for circumference; and, if one-ninth of an inch be used as the unit for the half-size addition, such an even progression without "skip" or "break" is made possible over a longer series of sizes, and it has the additional advantage of establishing a uniformity of denomination in the fractions used, both for girth and length.

It becomes necessary now to see the relations these units of measurement bear to those used for like purposes in other countries.*

French methods dominate Continental shoe practice, and in France we find that both the Paris point and centimetres are used.

A table is here inserted showing the relative Paris points, centimetres, and English inch and English sizes.

Having said so much about the units used for length, the girth units now demand attention.

The usual English procedure is to add one-quarter of an inch between each full size for increase of girths at the joint and instep, as shown in the following examples taken from standard tables:—

Gentlemen's size 8, $8\frac{1}{2}$ joint, 9 instep; gentlemen's size 9, $8\frac{3}{4}$ joint, $9\frac{1}{4}$ instep; or women's size 4, $7\frac{1}{2}$ joint, 8 instep; women's size 5, $7\frac{3}{4}$ joint, $8\frac{1}{4}$ instep; or equivalent to a one-eighth difference for half-sizes.

The French procedure is to add three-fourths of the Paris point (2-15in.) from size to size at the joint and instep, i.e., when the same Paris points are used for the length. If the centimetre is used, then two-thirds of the centimetre is taken for the length (4-15in.), and half-centimetre (2-15in.) difference from size to size for the girth increase, joint and instep.

Other makers use half-centimetre (2-15in.) for length addition, and one-third centimetre (1-12in.) for girth additions.

Various other combinations of these methods are favoured by different Continental manufacturers.

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*In the United States and Canada the English inch and its parts are used in the compilation of their standard tables. The tables used are not easy to compare with English tables, simply because the Americans divide their points of measurement into ball, waist, instep, heel, and ankle.

Various considerations enter into the question of the differences that should be made for fittings, and the units that should be employed. Obviously, to make a universal rise of half an inch for every class of last, in the manner usually done, is plainly wrong. Such an allowance is not even the average yielded by a large number of statistics. In this particular the Continental makers are no more advanced than English manufacturers, and the American manufacturers are alike in making equal differences for every fitting.

Now, a "fitting" represents a "type"; and, whilst all feet are alike in their general plan and construction, they are by no means alike in the proportions that are maintained between their various parts.

The narrower the joint measure, the greater is the difference required in the girth of the joint and instep.

The greater the joint measure, the less the difference required between joint and instep.

The feet with narrow joint measure not only appear to be more arched; they actually are so; and these feet with the narrow joint measure and high rise of the instep represent a type in which these features are accompanied by an ankle measurement which is greater than the joint measure. Stated generally, the ankle measure is equal to the joint measure. In finely-arched feet this ankle measurement is always greater than the joint measurement. The muscles are always "taut" in this type of foot, and one gets hence a tenser state of the annular ligament. These feet are always associated with a shorter heel bone (or less projecting heel bone), and the bulk of the muscle with a lower attachment than in the low arched feet. These are all factors making for a fully developed condition of the ankle. Indeed, the "fittings" may be determined by the shape and character of the heel.

With the long, projecting heel, the calf is smaller, and the bulk of it is disposed higher up the leg.

The calf muscle is differently related to the short heel, because a short lever requires at least a more immediate, if not a greater, power to lift it. Small muscles have a quicker action, as may be seen in the action of the many small muscles in the sole of the foot. The heel of the infant foot being very small and undeveloped, the calf-muscle of the infant, by its disposition, gives an ankle larger in the infant in proportion to adult feet. As the heel grows in length backwards, so the larger part of the calf becomes situated higher up the leg; and in girls (11's

to 1's) the smallest ankle measure compared with the joint is found. Feet with a long heel projecting backwards are low-arched, and in adult feet with a heel so shaped the ankle dimension is smallest.

Thus we find that varied types having their own characteristics as stated above are represented by these various fittings, rendering an even addition to the joint for each fitting erroneous.

A woman's foot, 6-fitting, for instance, rarely has an increase of more than one-eighth to a quarter of an inch in the instep measurement, whilst a lady's smart, well-arched foot with narrow joint measure may have as much as one inch difference, and rarely less than three-quarters of an inch.

If, therefore, adopting the unit of one-ninth of an inch, a scale of six fittings be instituted, with a rise for the largest (6) fitting of two-ninths, and for the smallest (1) fitting of seven-ninths of an inch, a wider range of feet would be more satisfactorily fitted from stock lasts than can be possible by the perpetuation of the old flat rate scale.

Such a table of joint and instep measurements would work out as the examples herewith:—

INSTEP MEASUREMENT.

ONE-FITTING.			THREE-FITTING.		
Size.	Joint.	Instep.	Size.	Joint.	Instep.
1	$6\frac{5}{9}$	$7\frac{3}{9}$	1	7	$7\frac{5}{9}$
2	$6\frac{7}{9}$	$7\frac{5}{9}$	2	$7\frac{2}{9}$	$7\frac{7}{9}$
3	7	$7\frac{7}{9}$	3	$7\frac{4}{9}$	8
4	$7\frac{2}{9}$	$8\frac{1}{9}$	4	$7\frac{6}{9}$	$8\frac{2}{9}$
5	$7\frac{4}{9}$	$8\frac{3}{9}$	5	$7\frac{8}{9}$	$8\frac{4}{9}$
6	$7\frac{6}{9}$	$8\frac{5}{9}$	6	$8\frac{8}{9}$	$8\frac{6}{9}$
7	$7\frac{8}{9}$	$8\frac{7}{9}$	7	$8\frac{3}{9}$	$8\frac{8}{9}$

TWO-FITTING.			FOUR-FITTING.		
Size.	Joint.	Instep.	Size.	Joint.	Instep.
1	$6\frac{7}{9}$	$7\frac{4}{9}$	1	$7\frac{2}{9}$	$7\frac{6}{9}$
2	7	$7\frac{6}{9}$	2	$7\frac{4}{9}$	$7\frac{8}{9}$
3	$7\frac{2}{9}$	$7\frac{8}{9}$	3	$7\frac{6}{9}$	$8\frac{1}{9}$
4	$7\frac{4}{9}$	$8\frac{1}{9}$	4	$7\frac{8}{9}$	$8\frac{3}{9}$
5	$7\frac{6}{9}$	$8\frac{3}{9}$	5	$8\frac{1}{9}$	$8\frac{5}{9}$
6	$7\frac{7}{9}$	$8\frac{5}{9}$	6	$8\frac{3}{9}$	$8\frac{7}{9}$
7	$8\frac{1}{9}$	$8\frac{7}{9}$	7	$8\frac{5}{9}$	9

Five-fitting.			Six-fitting.		
Size.	Joint.	Instep.	Size.	Joint.	Instep.
1	$7\frac{4}{9}$	$7\frac{7}{9}$	1	$7\frac{6}{9}$	$7\frac{8}{9}$
2	$7\frac{6}{9}$	8	2	$7\frac{8}{9}$	$8\frac{1}{9}$
3	$7\frac{8}{9}$	$8\frac{2}{9}$	3	$8\frac{1}{9}$	$8\frac{3}{9}$
4	$8\frac{1}{9}$	$8\frac{4}{9}$	4	$8\frac{3}{9}$	$8\frac{5}{9}$
5	$8\frac{3}{9}$	$8\frac{6}{9}$	5	$8\frac{5}{9}$	$8\frac{7}{9}$
6	$8\frac{5}{9}$	$8\frac{8}{9}$	6	$8\frac{7}{9}$	9
7	$8\frac{7}{9}$	$9\frac{1}{9}$	7	9	$9\frac{2}{9}$

Difference between joint and instep for various fittings under this scale:—

1	2	3	4	5	6
$\frac{7}{9}$	$\frac{6}{9}$	$\frac{5}{9}$	$\frac{4}{9}$	$\frac{3}{9}$	$\frac{2}{9}$

Chapter V.

THE INSOLE PATTERN.

An American writer in the "Superintendent and Foreman" claims that every man who makes model "lasts, and that every person who is at all interested in last making, should have always in front of him several full-size diagrams of bottoms of feet, of different sizes and swings; . . . it would prevent them from wandering too far from their text." This is not at all unlike the late Lord Salisbury's advice to budding Imperialists—to study Imperial questions with the aid of a large scale map.

The point of the advice in both cases is to keep a tight grip of facts obtained under the best conditions; and, in the particular case of the shoe manufacturer, it is to remember that shoes are for actual feet, and that an intimate acquaintance with the realities of the conditions will prevent, as our American friend expresses it, a "too-far travelling from our text."

The facts concerning the "form" and the "activity" of the foot have been closely dealt with; it now becomes necessary to show how the manufacturer of shoes is to provide for the conditions already observed.

First, the shape of the foot has to be regarded. That is the determining influence in the "form" of the insole at one end of the scale.

Second, the character of work to be made upon the last of which this insole is the "plan," embodies all the influences determining the shape at the other extreme of the scale.

The main facts in the second group of which cognisance must be taken are:—

(a) That, as the heel is raised by the addition to the sole of a built heel, and also as the foot attains the digitigrade position, the amount of the surface contact of the forepart is shortened;

(b) That with the raising of the heel there is also a slight but perceptible eversion of the great toe from the Meyer line.

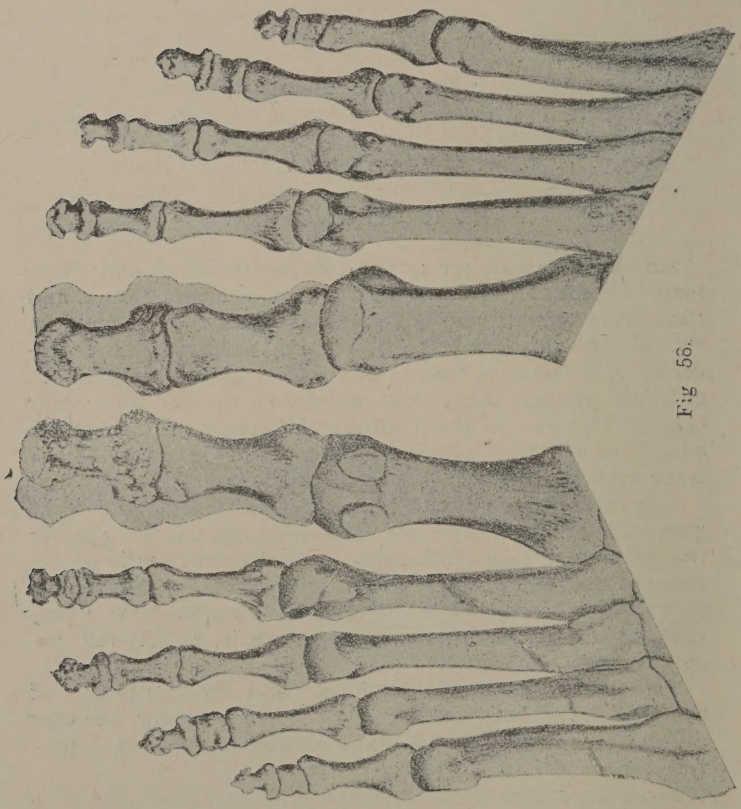


Fig 56.

If the great toe be raised whilst the foot is in the plantigrade position, the toe will be seen to move towards the middle line of the foot, as shown by reference to figure 58, where the new position of the great toe is indicated by a shaded outline. The extent of this eversion has been determined by actual experience with foot prints; and it is found, on an average, for adults, to be, for every half-inch

the foot is raised, one-ninth of an inch; and that the surface contact of the forepart is reduced one-eighteenth of an inch for each half-inch the heel is raised from the ground, as illustrated in figure 59.

Looking again at figure 58, it will be seen that the line drawn from A to B, as previously explained in Chapter II., cuts off the two outer toes with the part of the foot behind them, and in front of the heel, and that the area thus cut off by this line forms a kind of set-off in the ground plan to the main structure, and that the observation of this feature gives a physiological basis for sole-pattern construction; and that all methods of sole-pattern construction

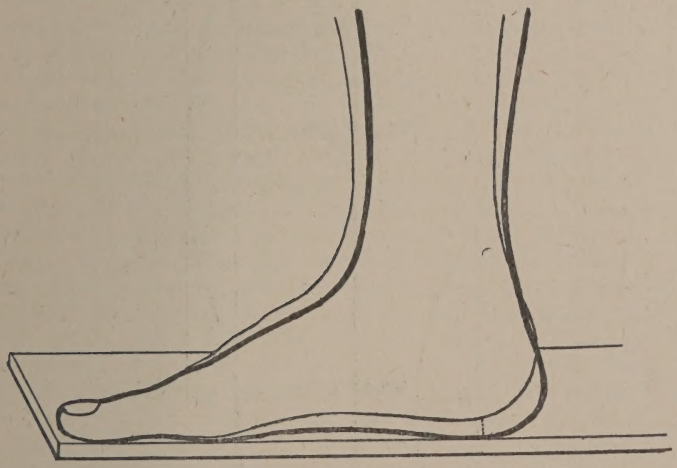


Fig. 59.

have as their initial basis a parallellogram corresponding to the demarcation on this figure.

Certain other data are necessary for the development of the subject of the insole shape.

It is necessary to fix the position relative to the length, of the essential points in the sole pattern. These are found to be for the:—

(1) Inside joint, two-sevenths of the length from the toe;

(2) Outside joint, two-sevenths of the length from the toe;

(3) Widest part of the seat, one-sixth of the length from the toe.

The line connecting 1 and 2 in the figure 60 is referred to as the "tread line."

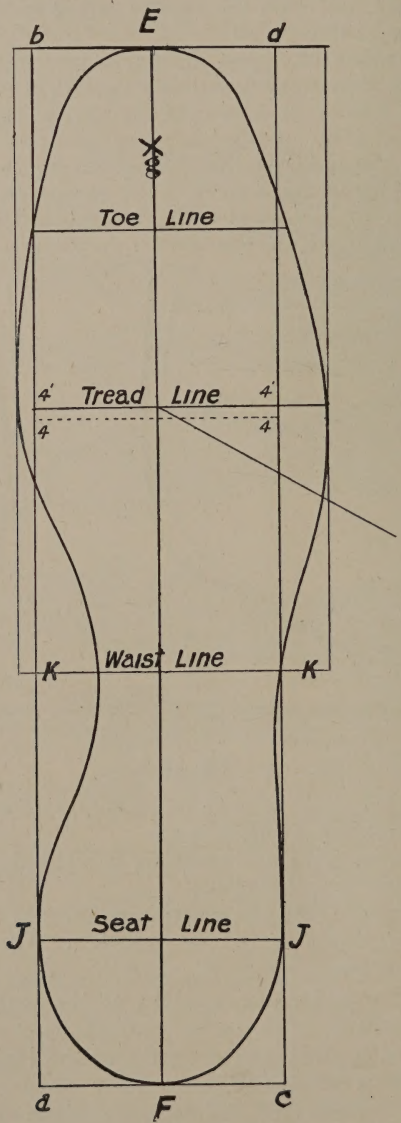


Fig. 60.

The line midway between 1 and 3 is referred to as the "waist line."

No. 3 becomes the "seat line."

Now, it will be found that all undistorted feet are, so far as their sole plan is concerned, conformable to these proportions. The difference that is made by growth and development is, in the main, the development of the arch of the foot with the corresponding differences in the upper part of the foot, of which details have already been given; and the difference in the slight eversion of the great toe from the Meyer line, a consequence of the development of the arch, and the use of the foot, a concomitant of its growth.

Sexual differences are associated only with a difference in the relative length of the first and second toes (if at all), and the foot of the woman and child in its sole plan conforms essentially to the proportions stated. We have, therefore, material at hand for the structure of the insole shape, subject to figures of width at the essential parts.

So far as the shape of the toe is concerned, so long as the demands of the Meyer line are conformed to, and room is accorded to the little toe, this may be pointed or square; though the first shape may demand an increased length, just so far as the demands of a harmonious shape are imperilled by the relative positions of the great toe and little toe and the width. That is to say, sometimes the sole width may be so great, that to get the shape pointed, and yet to have regard to the critical points, compels (unless a stumpy-looking shape is to result) an increased length. A foot such as is given in plan below, for instance, it would not be possible to provide with a pointed shape, except by adding extra length.

There is not need to labour this point, as it is probably well understood; and we shall now proceed on the basis of facts given to show how an insole pattern may be constructed.

For this purpose (see figure 60), size 7 men's is selected, and the process is as follows:—

1. Describe a parallellogram, the length of the insole to be constructed, A B, B D (in this case, size 7, $10\frac{2}{3}$ of an inch), and the smaller side the width of the seat ($2\frac{1}{2}$ inches), C D.
2. The usual addition to the length of the foot for an ordinary shape toe and style of last being three sizes, the length of the foot may be taken as 4.

3. Bisect C D and A B. Join the points of bisections by the centre length line, E F.

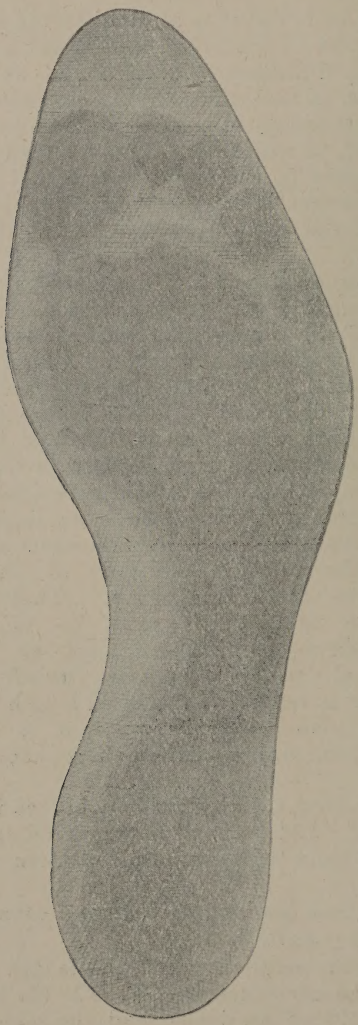


FIG. 61.

4. Mark upon E F, from F, the length of the foot (i.e., size 4), point G.

5. Along E F, from G, set off an amount equal to two-sevenths of G F that will mark the position of the "tread line," H H (advance tread line 1-18 inch for every half-inch of heel elevation).
6. One-sixth of F G will mark the position of the "seat line," J J.
7. Midway between the seat line and the tread line will mark the position of the waist line, K K.
8. Midway between the tread line and E on A B is the position of the "toe line."
9. Mark the outside joint position.

The next process is to distribute the measurements of the bottom of the foot in relation to the middle line, E F, in accord with the facts given in the chapter on the "Form of the Foot." Though we have a centre line in the parallellogram used for the basis of construction, that does not imply that our resulting sole form is to be even-sided. Of the distribution of the measurement we must next treat.

1. Subtract the "seat width" (say $2\frac{1}{2}$in.) from the forepart, or "tread width" (say $3\frac{1}{4}$in.)
2. Divide the amount so subtracted into four equal parts. On the outside of the tread line, beyond the point where it is cut by the line C D, mark off a distance equal to three of these parts; and on the same tread line beyond the point where it is cut by the line A B, a distance equal to one of these parts.
3. It is usual to set off one-third of the waist width on the inner side of the waist line, and the balance of the width to the outer side.

Figure 61 is an insole form with a direct vaseline print thereon.

The grade for bottom measurements can, of course, be obtained by the ordinary method of dividing lines proportionate to each other. The question of grading, however, will be dealt with in full in a subsequent chapter.

Chapter VI.

THE LAST.

The principles determining the practice of last-making, and the form of lasts, are, obviously, those, in the main, which have relation to the form and shape of the human foot; and we may, therefore, agree with Doctor Ellis in his statement that "the last should be the shape of the foot." Like so many, apparently simple, statements of truth, this is a little deceiving, and we are not long in finding that here we have only a partial solution of a somewhat vexed question.

It is, no doubt, true that the last ought to be the shape of the foot; but the question at once arises, Which shape?

Man has in his organism a summary of the lower forms of life; and in the form of his organism he has not a little of the perplexity, which is the price of his supremacy in the animal world. For, whatever the horse or the elephant may be, Man is not simply plantigrade or digitigrade; he is both, and more. His foot has many shapes—a different shape in repose to that assumed in activity, and in the transition from repose to activity, he (more often she) may even be unguligrade.*

Neither does every person perform the same or identical uses with the foot; so that the prevailing use and the most constant position of the foot become factors in determining the correct form of lasts.

For example, the most constant position of the foot of a navvy is not that of a coachman. As to shape and dimension, form and outline, the feet of the two men might be alike, but, the use being altogether different, a different shape in the footwear becomes necessary, and hence, also,

* An animal walking on the tips of its digits.

a different shape in the last, upon which such footwear must be constructed.

Then, too, the claims of the process of manufacture have to be regarded. The last ought to be the shape of the foot. Yet not always does economic manufacture permit of all the attention that should be paid to this side of the question. In fact, it may be stated as a principle that the more complex the methods of manufacture, the greater is the departure usually called for in the shape of the resulting last, found to be necessary for the economic conduct of the factory process, differentiating it from that which may be established as the "norm" or "standard."

Then, further, the shoemaker has to regard the prevailing fashion. Not that we have any right, or business, to sacrifice essential truth even to the demands of a too clamant fashion. In this matter, however, as in so many others, knowledge is the solvent of many difficulties. Knowledge of the foot, and of what is due to the normal performance of its activities, will enable something to be done towards serving Fashion, without hurting the foot For example, one may make a pointed-toe shoe, and yet have proper provision for the foot, if one knows all about the foot.

Fashion, then, contributes her quota to the problem.

One other thing has to be brought into the calculation, and that is the rigidity (or pliability) of the material of which the footwear is made. It will be found in actual experience that this is an important factor determinative of the form of the last.

We may agree, then, with Dr. Ellis, subject to what has been stated as to its variable nature, that "the last must be the shape of the foot."

The other factors by which its shape is determined are as follow:—

(a) The mode of the foot's activity;
(b) The prevailing use of the footwear;
(c) Demands of Fashion;
(d) Processes of manufacture;
(e) Style in the footwear;
(f) Materials used in the boot or shoe.

Remembering all that has been said in Chapter II. about the complemental character of the feet, under no circumstances may lasts aiming at representing the "shape of the foot" be straight. There are reasons without number why they should be, and must be, right and left. The treat-

ment of the sole area has been dealt with in the chapter on the "Insole Pattern."

Dr. Ellis, in endeavouring to show us his idea of a perfect last, has depicted for us a fearful and wonderful contrivance, which would appear to be admirably adapted for a foot when perfectly at rest, but which could not possibly fit a foot in action without developing very big wrinkles in the boot, behind the joint of the great toe, and ultimately turning up at the toe and having generally a very ugly appearance.

It is futile for Dr. Ellis to tell us that "that which is natural is beautiful." Surely a boot is not a "natural,"

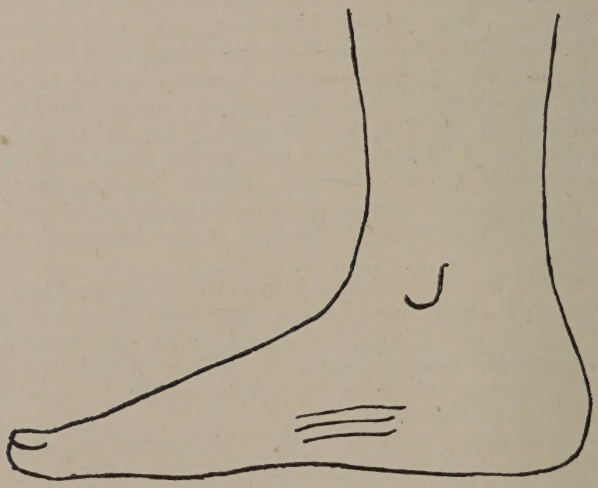


Fig 62.

but an artificial, thing; and we have to remember that in the construction of the boot we have to regard the principles of utility which are operative in this field of practice.

Figure 62 roughly depicts the "position of immobility" of the foot. It is not correct to speak of the state of the foot when standing at ease as the position of rest; because this position may be assumed in the performance of a certain amount of work, and this constitutes, to a limited degree, a position of activity. It will, therefore, be best to refer to the condition, and shape, which the foot thus assumes, as the position of immobility, and this position is depicted in figure 62. It is a position to which the foot constantly reverts, and one which is well understood.

Ought the last to be a model of the foot in any one only of its positions, either of immobility or activity? Obviously, this cannot be so; and in this fact we find the second point, for a definition that shall picture for us the structure of the ideal last, and we state the matter as follows:—

"For every purpose, the form or shape of the last ought to be a 'mean' shape, or form between the extreme shapes of immobility (figure 62) and the positions given by the most constant form of the foot's activity."

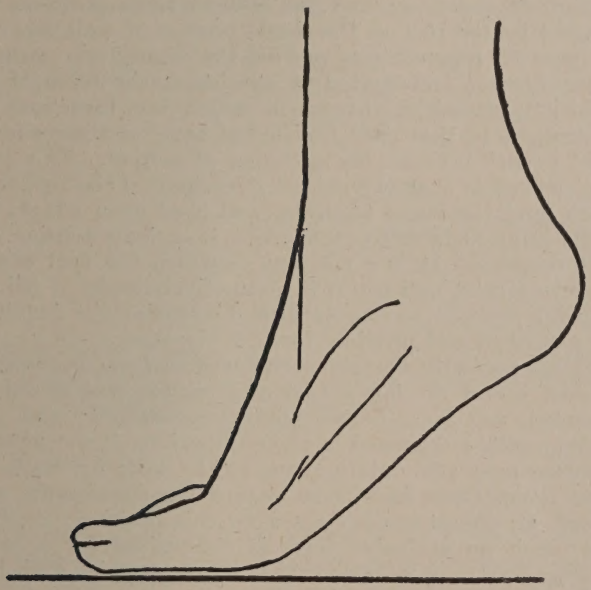


Fig. 63.

The jumping-off place, therefore, in the determination of the form of any last, for any purpose, is the position of immobility.

This one position being tolerably fixed and certain, the other main factor determining the shape (in so far as the method of the foot's activity determines the form of the last) becomes the extreme position of activity, or the most constant of these positions.

The lasts for walking boots have to regard, first and foremost, the proper activity of the foot; second, the best appearance of the finished boot. Whether Doctor Ellis's last would fit the ideal foot—never yet found—it is not possible

to say; all that we know is that it will not do for feet used in the manner of which we know, and as we have met them; and the reason wherefore this last is to be condemned is just because it regards in its structure too exclusively the position of immobility pictured in figure 62, and too little the position of activity, of which an extreme form is shown in a further sketch.

Or, to speak in strictly scientific language, this last regards too much the plantigrade, and never at all the digitigrade, position; and yet both of these positions are assumed by the foot in the single process of walking.

Figure 63 represents in outline the digitigrade position.

One further fact that does not lessen the force of the definition, stated as that upon which the form may be determined, is, that the "position of rest" is always found in a "mean" between the extremes of motion. This position, defined as that of the least stretching of the ligaments which bind the bones together, and most even adaptation of the joint surfaces to each other, is of least tension and least pressure. It is a position to which the foot always tends in repose, and which it instinctively seeks in pain.

Such a position, so important and essential, the definition has regard to and provides for.

A last perfectly flat along the bottom from heel-end to toe-end would do for a foot that never was flexed, or extended, and for a person who never walked; and, just as the positions assumed in the occupations of a coachman or motor-man are mainly these, so the lasts for boots for these occupations have most regard to plantigrade, and, indeed, an almost entire regard for this position; so, likewise, such an exclusive form is not suited for a lady's walking boot or shoe, nor for the last upon which such boot or shoe would be constructed.

It is fundamental that the last should have regard to the position of extreme activity.

It has now to be shown how far the positions of activity are different from those of immobility, and what the constant factor is in the departure from the plantigrade to the digitigrade position; for this knowledge will help to a true understanding of that which is called "spring" in lasts.

Assuming a ground-line passing through the ball of the great toe (or the corresponding position on the last), and the seat raised to the distance demanded by the height of the heel, parallel to that ground-line: "Pitch" is the elevation of the seat under these conditions.

It is shown diagrammatically in figure 64.

"Spring" is the elevation of the toe above the same line under the same conditions.

That is also shown in figure 64.

Some authors refer to spring as the elevation of the toe from the ground, the seat not being raised; and this results in a long disquisition on "front spring" and "back spring," and flat contradictions of each other.

A settled definition is highly desirable, and it is hoped the effort made herein for this purpose may be acceptable to others.

Now, the great toe rests on the ground in both the digitigrade and plantigrade forms; but what it is essential to remember in connection therewith is that there is no bending of the great toe itself. The rigidity of the great

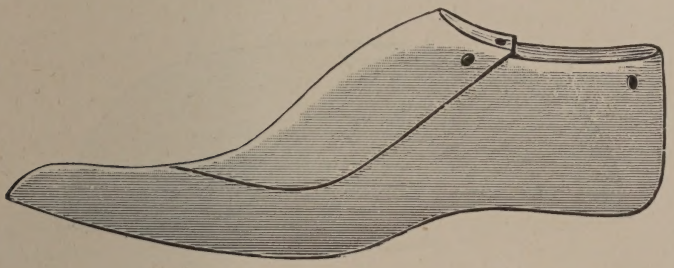


Fig. 64.

toe is emphasised by every detail of its structure, and by the facts obtained by an observation of the mode of union of the metatarsals with the tarsal bones. In these joints a slight revolving motion can take place in the fourth and fifth toes, and is used for the purpose of adjusting inequalities in the contact with the ground; whilst, in the corresponding point of the three inner toes, scarcely any motion can occur—a provision by which additional strength is given to the inner side of the foot, upon which the weight of the body very largely falls.

This fact of structure, while it lends additional support to the contention that the deficiencies of one foot are more than balanced by the support given by the other, also effectually disposes of any contention that "spring" has, or should have, any relation to, or connection with, the raising of the seat. The digitigrade position is attained as shown in figure 63, without any bending of the great toe.

There is dorsi-flexion, but that is another matter, and has no relation to the present argument.

"Spring" in the last has reference, therefore, to, and is regulated by, something other than the form given by the foot's activity—as a matter of fact, almost exclusively by the rigidity or pliability of the materials of which the boot is made, and for reasons associated with the other reasonings regarding the position of rest.

A special development of the ball of the foot, through extra-sized sesamoid bones, or through a shortened plantar fascia, is not strictly an essential factor in determining the amount of spring in standard lasts. These peculiarities have, however, to be taken into account in designing lasts for special work; in fact, in that region of last formation concerned with the adaptation and formation of lasts. for such conditions as talipes.

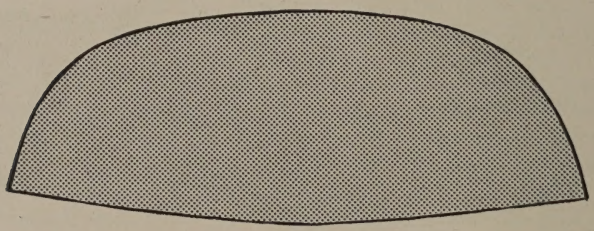


Fig. 65.

A boot may have a heel of one and a-quarter inches, with the toe quite dead; or, if one likes the statement better, with an entire absence of "spring"—flat from joint to toe. This, indeed, is a common practice in the West-end handsewn trade, and it is only possible because of the high grade of workmanship associated with these productions, ensuring the greatest flexibility, and for the restrained use to which such footwear is subjected.

To associate this character of last, however, with nailed work is, manifestly, absurd, and it becomes clear, when we speak of "spring" in this connection, that it has nought to do with the raising of the seat, but all and everything to do with the rigidity of the boot itself.

So far as "spring" is demanded in lasts at all, it is due, fundamentally, to the shape of the under part of the great toe.

Thus much for "spring."

What shall be said about "pitch"?

That it has reference to the height of the heel, and must be duly provided for in the upward sweep of the waist.

The higher the heel, the greater should be the difference between the height (or depth) of the front and back of the heel.

If this be not regarded, a perfect "range" is lost in the finished shoe. Thus, with a Louis heel, shown in figure 68, there is a noticeable difference between the front and the back measurement of the heel. In fact, "range" may be

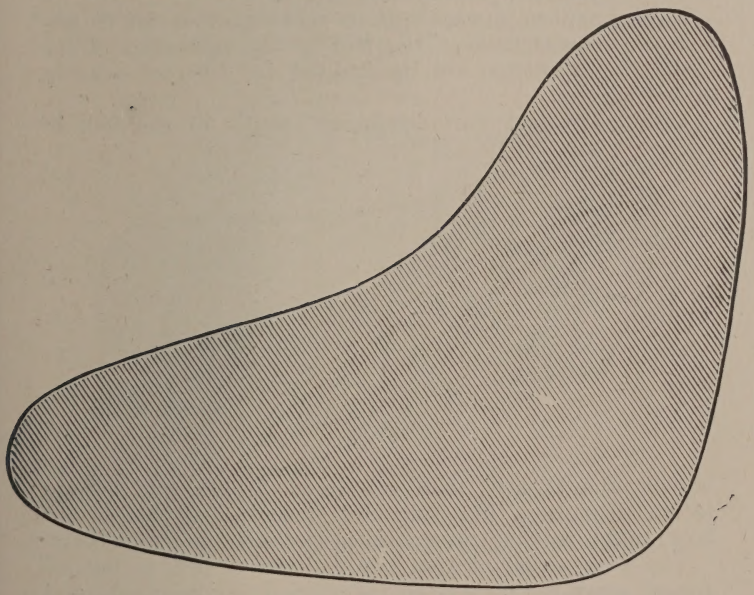


Fig. 66.

defined as the harmonious blending of "pitch" and "spring," and the proper placing, and positioning, of the ball of the last for the varying heights of heel—i.e., the allowance for the fact that the line of contact is more forward, as explained in Chapter V. The lower the heel, the nearer the approach to the plantigrade position, and the longer the forepart. The higher the heel, the nearer the approach to the digitigrade position, and the shorter the forepart.

Referring to the whole sole length of the last, it may be stated, generally, that this is usually too great. The length of the sole of the last (measured by a tape flat and close to

the bottom) ought, if the proper formation of the seat is regarded, to be at least one size shorter than the nominal length of the last, measured from heel-end to toe-end with a size-stick.

The last must, then, be a "mean" form, or else the shoe itself must be such as to be adaptable to the varying shapes of the foot, in which case, as with the shoe of the ballet dancer, it may be made with regard to one position of the foot only, viz., the plantigrade.

Having said so much about its side elevation, let us see how the requirements of the foot in the treatment of its remaining substance are interpreted by different schools of last-makers.

Taking the fact that the inner margin of the foot is

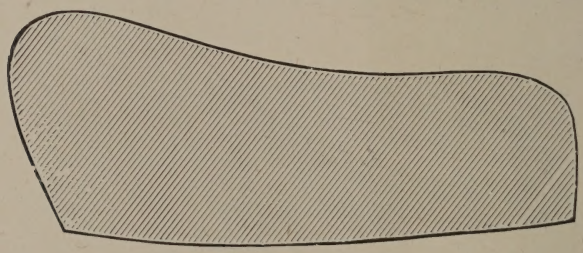


Fig. 67.

higher, and thicker, than the outer margin, and has no lateral expansion like the outer margin has, let us see how far this is being recognised by present-day last-makers.

The recognition of this lastly-observed fact is but of recent years (so far as factory goods are concerned), and may be set down as one of the lessons of the Yankee invasion.

Figure 65 represents a cross-sectional view of the joint of a standard English type of last ten years ago. It will be noted that the sections are almost bi-laterally symmetrical, and do not by any means recognise the fact, to which attention has been drawn, viz., that the inner margin of the foot is higher and thicker than the outer margin.

Looking, however, at figure 66, where we have a representation of a cross-section of a modern last of the English-American type, this fact of a difference in the sides of the foot is clearly recognised. The present danger, indeed, is that too much is being made of this discovery.

There is already a tendency to design lasts with over-much inside instep stuff, and the angular joint crease, the outcome of this abuse, can be seen in the railway coach or tramcar any morning it is looked for diligently enough.

One advantage the American last has results from the use by the American shoemakers of a waist measure, smaller than the joint measure, to which the last is adapted. This is the secret of much that has rendered American shoes commendable to English wearers, giving a "grip" and feeling of snugness, without pressure, and permitting of the extra length favoured by American model makers,

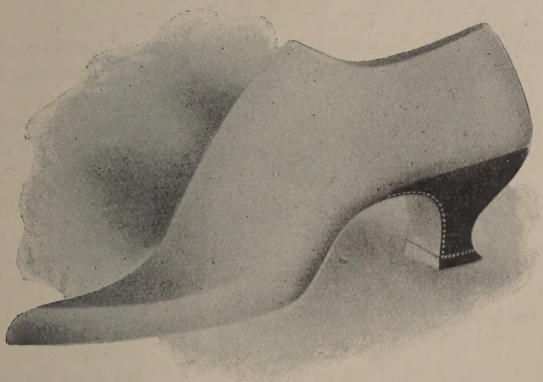


Fig. 68.

yet not allowing the sliding forward of the foot within the shoe.

It has already been said that in planning the sole form the rights of the great toe must ever be regarded. If you will but allow the due place to this important member of the foot, and not altogether forget the fifth toe, you may have your shoe pointed or square, round point or needle point, and yet have comfort, and break no law of hygiene or precept of anatomy. And just here it must also be said that the great toe and the little toe have certain rights on the upper territory of the last. Whilst it is essential that the rights in the planning must be regarded, so the rights of these parts of the foot are but only half-yielded, if the construction of the last in its upper part be not also properly carried out. The first must be done; the second, equally, must not be left undone.

The great toe of a man's foot, average size 7, is 15-16th of

an inch thick. The last dare not be less in substance, in any case, at the point on the last corresponding to the same point in the foot The small toe of same size man's foot will be found to average $\frac{5}{8}$th of an inch thick. Here, again, the substance of the last must never be less; but, as will presently be shown, usually it must be greater than the substance of the foot.

The factors that differentiate the thickness in the last for the great toe are:

(a) When the last is but little longer than the foot; then the last must at the corresponding part be thicker than the foot.

(b) When there is an incomplete correspondence of curvature at toe-end between the last and the foot; then, (1) when the curvature is greater than the foot, and the last longer than the foot, the substance of the last may be exactly that of the foot. (2- When the curvature of the last is less than that of the foot, then the thickness of the last must be greater than that of the foot. (3) Case toes, also, when used, demand a greater thickness of the last.

The factors that differentiate thickness for the little toe are:

(a) Bottom width less than that of the foot requiring greater thickness (as much as 50 per cent. more) in the last than the foot.

(b) Straight, sharp line in the last, in place of bold outer curve, will demand much greater thickness in the last, especially if associated with narrowed bottom.

(c) Pronounced rise from point to instep demands greater thickness in the last at the point corresponding to the fifth toe.

These, then, are the pure principles determining the form at these points. The structure has to be made, however, with reference to the after processes of manufacture, and just here, in some cases of the application of these principles, difficulties are made for the lasting processes; and, just leaving for the moment our subject proper, this difficulty will be discussed.

Assuming a shortened last, with a narrow bottom width, the application of the principles for the shaping of the

last at the points of the great toe and little toe would result in a last with three high prominences, with a hollow space between. Thus, in figure 69, No. 1 would represent the prominence of the joint of the great toe; No. 2 the prominence of the fifth toe; and No. 3 the thickened toe-end. The middle would represent a depression, A. The problem for the lasting process is to pull the upper tightly over 1, 2, and 3, and yet block down to A. Under a machine process of lasting, this problem would probably be found, with due regard to rapidity of manufacture, to be incapable of solution.

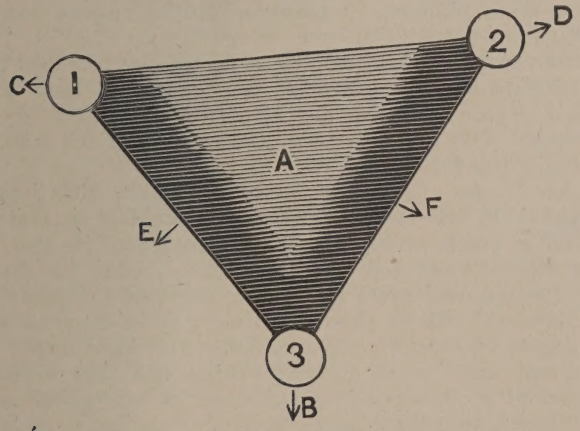


Fig. 69.

Under a hand process it can only be accomplished by having an extra long upper; then first pulling over at toe, and tightly at points 1 and 2. Then releasing the upper at point 3, straining down at e and f; then relasting at c, d, and b. The upper would then be tightly lasted over all points, and yet close down to the last at A.*

It should also be noted, with a last so formed as in the case stated, that if the upper be not properly lasted down

* The order of the lasting process would be thus:—

1. Pull over at 3=b.
2. Pull over at 1 and 2=c, d.
3. Release at 3b.
4. Pull over e and f (fix very firmly).
5. Re-last c1, d2.
6. Re-last b3.

at A, the whole purpose of the peculiar last formation is lost, and the net result would be a smaller-fitting shoe than the structure of the last would infer.

Seeing, then, that, under the conditions set out, it would not be possible under machine-lasting processes to properly block the upper to the last, if shaped in this way, some modification of the form is demanded that shall yet provide for the full requirements of the foot. This, shortly, amounts to making the last rounder, i.e., higher in the middle of the upper structure, and rounder, more convex in the bottom.

This is an influence of manufacture having an adverse influence upon the form.

It has been pointed out, also, that case or box toes have an influence upon the form of the toe-end of last. In a limited degree, toe-caps are also to be included in this influence. This is a case where the rigidity of the material influences the form.

If hard boxes are used in the toes of shoes, with little or no spring in the lasts (even though the last was at the toe-end as thick as the toe of the boot), and if, also, the shoes are cut from heavy, coarse leather, when the foot is bent, the box will press into the knuckle of the great toe, and it would not be possible to walk in such shoes with any degree of comfort. Heavy boxes and hard upper leathers, and rigid soles, demand (whilst the last must be at least of a corresponding thickness at the equal point for the great toe) that it shall have more spring, to counteract these other influences.

Toecaps demand a small difference in the shaping of the sides of the toe of the last, and also a certain small increase in the height of the toe. Between the first and second phalanges of the great toe there is a side depression amounting, in the average male foot, to one-quarter of an inch. There is no need, therefore, that the last at this point should be bulgy and thick; and there is every reason why it should be thinned a little, for by so doing (in the case of toecapped work) room is allowed for the seam made by the cap; and thus, also, for securing a level range, and smart appearance to the boot, with no loss of comfort to the wearer. It is desirable, however, that the toe of the last should be just slightly higher, and thicker, when toecapped work is to be made upon the last. It is also possible, with the same basal toe width, to get a much narrower appearance to the toe of the boot, by making the toe of the last higher in the central upper part.

The formation of the seat of the last should enable the seat of the heel of the foot to sink into the seat of the shoe, just like the rounded head of bone fits its socket in a ball and socket joint. The seat of the foot is not dead flat, but convex, and demands a corresponding concavity in the shoe, and a last so shaped as to produce this. This is to get a snug fit in the heel, and to prevent all running over at the seat.

It also means the use, perchance, of two split lifts, and, perhaps, three; and just possibly this is one more of those influences of a process of manufacture the provision for which may be deemed a burden too heavy to be borne.

The practice of making an uneven surface to the bottom of the last is of doubtful merit in handsewn and in welted work, having regard to the tendency of the leather to curl up, and it would appear to be altogether undesirable in machine-sewn work. The inside ball may be higher, and in some classes of work this may be desirable; but in every case the sole should be flat.

It has to be remembered that in the strenuous use of the foot the great toe leaves the smaller toes, going over to the middle line of the body, leaving a space between the great toe and the little toe. The same action which presses it against the ground causes this movement also; but there is no flexing, no bending—it remains quite straight. Therefore, in lasts for shooting boots or athletic boots, more emphatic regard must be had to the straight inner margin. As this class of work is made frequently with extremely low heels, this point becomes more emphatic.

Along the outer border of the foot, it will be remembered, lies the fleshy mass of the extensor brevis digitorum muscle, giving roundness and plumpness to the form; this claims the regard of the last-maker, and to-day is receiving his regard.

All along the outer upper border of the foot should be a ridge, corresponding to the disposition of this muscle, and thus ensure a perfect-fitting shoe.

It is the action of this muscle that creates the greater difficulty in shoe fitting than in boot fitting. A shoe last must be so good as to produce, as it were, of its own merit, a perfect fit to the foot. A section of a shoe last is always essentially that of the court shoe section shown in figure 71. Particularly, there must be the recognition of this straight line in the upper-side territory of the last, the need for which is created by this muscle; and there must be no undue curvature to the waist at its middle outer edge.

In figures 71-72 are given sections, joint and instep, of a court shoe last, in which the special provision for this

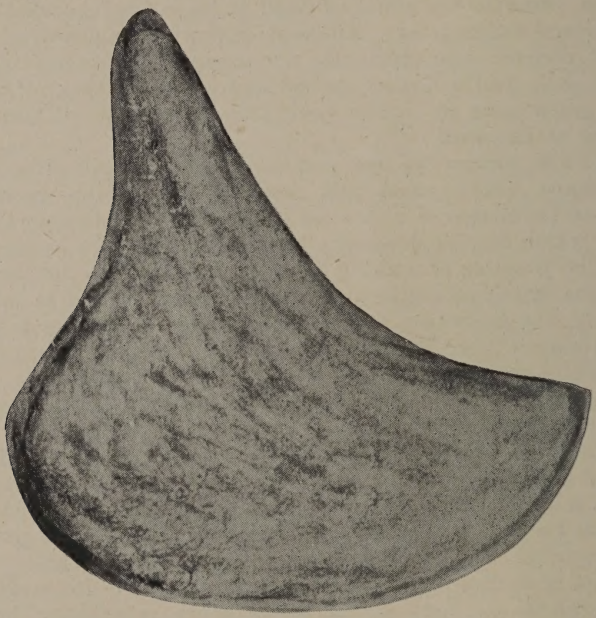


Fig. 71.

muscle is plainly seen. The greater the difficulty associated with the fitting of a particular type, the greater the

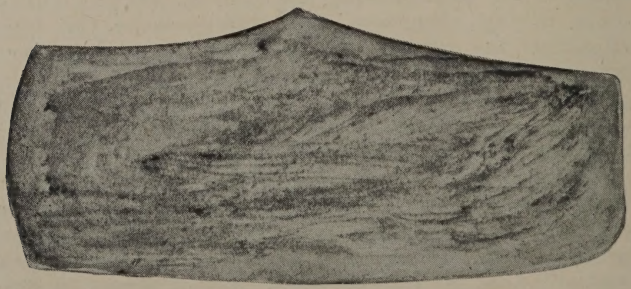


Fig. 72.

need that the model upon which it is built shall be the exact shape of the foot; and in this case of the court shoe

—admittedly difficult of fitting—a fit would be impossible, if the claims of the short extensor were not provided for in the structure of the last. It will also be observed, by the instep section, that the bulk of the stuff of the last is carried at the sides, and the "comb" brought up to a taper edge. This sharp comb, it may be seen by the joint section, is carried to the joint; if this were not so, the shoe would press into the foot at the root of the instep.

Special forms of boots or shoes demand special adaptation of the lasts. An ankle-strap shoe cannot be made upon a last upon which, in a perfectly satisfactory manner, might be made a child's lace or button boot.

The sharp ridge and high comb required for a court last are required also for the ankle-strap shoe. These characteristic structures are by no means necessary for a last upon which, for a foot of the same size and shape, might be made a Balmoral or button boot.

Here, perhaps, something ought to be said about the differences that are generally esteemed desirable in boot lasts. And here the historical method will help us. If the mind be thrown back to the Early Victorian period, when "shoes" were "buckle shoes" or "court shoes" for men, and "sandals" for ladies; when the "boots" were high boots, such as Wellingtons, Hessians, and Prince Georges; here was found a factor, other than the actual shape of the foot, dominating the form of the last. It requires but a limited experience to discover that a Wellington boot could not satisfactorily be made on a last yielding a section as shown for a man's court last. There was a need for something more than fitting the foot. There was a necessity for establishing conditions that would enable the wearer to get the boots on, notwithstanding the tradition of the period that the wearers were at times quite unable, from causes other than the cut of the boot or the shape of the last, to get the boots off.

Thus the thickened instep, characteristic of the "boot last," became associated with this term, and has survived to the period when "boot" has become the generic name for any style of footwear that is not a "shoe." In fact, this form of last is the persistence of an obsolete type. Some writers still think the thickened instep needed for button boots. In our opinion, with the light upper leathers now in use, a well-made shoe last is not alone suitable, but is desirable, for all ordinary boot work, men's or women's. The only exceptions one is inclined to make would be for men's stout Derby boots, shooting boots,

ladies' golfing and hockey boots, and work of the character typified by these examples.

Processes of manufacture have had, and will continue to have, a marked influence in modifying the form and material of lasts.

Herein consists, and is likely to continue to exist, the marked superiority of hand-made boots and shoes over those produced under machine methods.

Under the machine method the manufacturer is encompassed with a less flexible environment; and, just because of the departure from minor principles, and sometimes of essential principles—not always a voluntary departure on the part of the manufacturer, but an adaptation to the environment of the manufacture—just so is it necessary for the technologist to point out, and for the technical school to hold aloft, the essential principles that they may not be forgotten; that they may not escape final recognition on the day when, by the combined ingenuity of manufacturer and engineer, these true principles may ultimately be provided for, even under the process of wholesale production.

In the rapid manufacture under the McKay process, with the Consolidated lasting machine, it is necessary, for the insurance of a smart appearance in the finished boot, that the last shall have sharp edges and straight lines in the sole form, and a sharp waist line, well defined and distinct. Rapid methods involve the use of sole levellers and sole moulders, and with these the best results are obtained, when the last has well-defined sharp points.

Need it be said that in the foot itself there is nowhere a straight line?

Heel attachers work best with flat-seated lasts; the foot is least comfortable in boots made on such lasts.

American boots have, not uncommonly, this fault. The perfectly flat seat of work of this character, especially when there is much screw wire in the heel, is most uncomfortable and jarring, and a reason for the popularity of rubber-faced heels in work of this character.

VARIETIES OF LASTS.

The invention of a new last-holding device has been a potent aid in the variation of the form of the last as determined primarily by a mode of manufacture.

With the use of the old upright peg and socket for the holding of the iron last under the Blake-sewn process, a

thickening of the instep and heel of the last were necessary, in order that the last itself should not break in the process of hammering and heeling the shoe.

The introduction of the machine-welting process brought with it a new last-holding device, that should permit of the use of a wooden last and the maintenance of the upright position of the operative. Such a device is illustrated in figure 73.

A more developed form of the last-holding jack is Dilley's revolving stand.

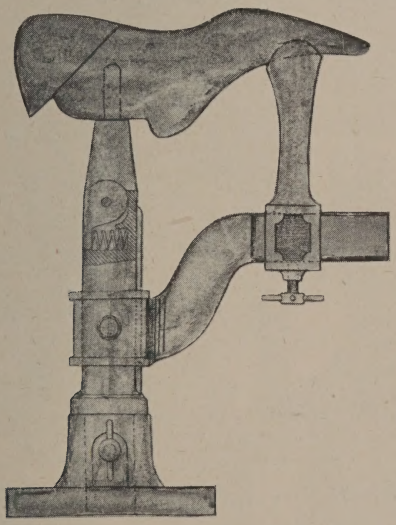


Fig. 73.

This invention consists in lasting and heeling stands embodying all the principles of the improved jack, but with further advantages peculiar to this invention. Thus a rotatable plate is provided, upon which is carried a pivoted support, controlled or maintained in the required position by means of a spring. This pivoted support is adapted to engage with the heel or rear portion of the last. There is also, as shown in the figure, a movable rubber-faced support for the toe of the last. The rotating plate is provided with a spring or other catch so arranged that the position required can be secured upon the base. The mobility of the hinder support is rendered thus to facilitate the removal of

the last as required. A rotating plate provided with a catch-piece is so arranged as to allow the rotating plate to be removed when in the necessary position in relation to the base upon which it rotates.

Figure 74 is a side view of Dilley's stand, showing the last in position, partly in section.

The last support a is pivoted at b to the revolving plate

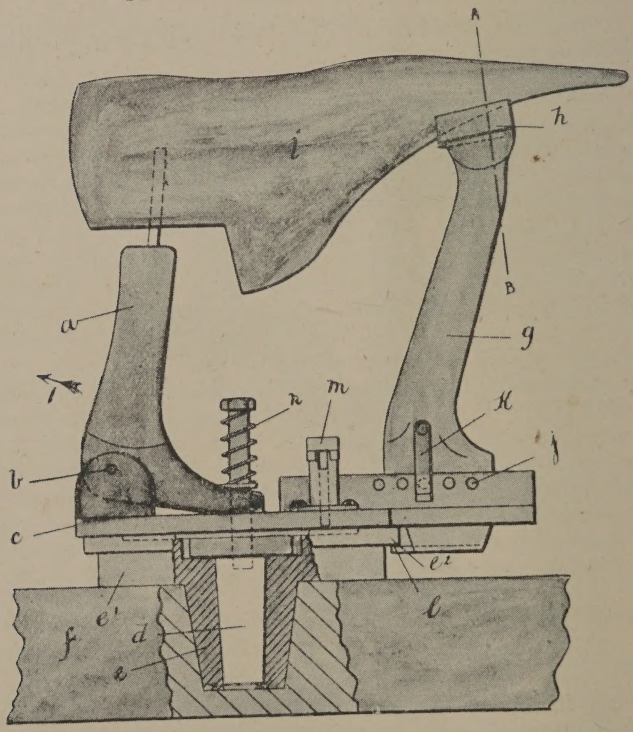


Fig. 74.

c, which has a projection d which engages in the socket e of the base e^1, which is secured to the bench or the like f in any suitable way. g is a second support, having in its upper end a pad h which may consist of indiarubber, felt, or the like, which is dovetailed in the support g, as shown in figure 81. The last i, when in use, is resting upon this pad as shown. A means is provided for adjusting the distance between the two supports a and g, consisting of a

series of holes j, into which engages the projection carried upon the spring k secured to the support g for the purpose of holding the support g in the desired position, j^1 being guides along which the projection in the support g slides, being held therein in a suitable manner. l is a projection carried by the revolving plate c, and engages on the rim e^2 of the base e^1, and is for the purpose of holding the revolving plate in its position relatively to the base, a slot l^1 being provided in the rim e^2 through which the projection l passes before being rotated. m is a pin which is caused to engage in a hole in the base when it is necessary to revolve the last. The spring n is for the purpose of holding the support a

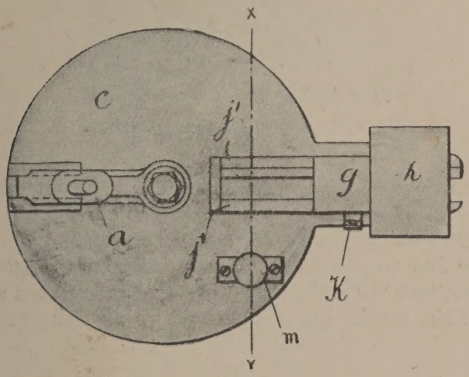


Fig. 75.

carrying the last i in its normal position, and when it is required to remove the boot or shoe from the last, the support a is moved in the direction of the arrow 1, when the last may then be removed without any damage to the leather.

Referring to figure 77, the socket e of the base plate e^1 is of hexagonal configuration, so that, when desired, the revolving plate may be removed therefrom, and the improved last support, as shown in figure 78, may then be inserted, when the device is used in the ordinary way.

In figure 79 is shown the modification of the base plate e^1, in which the socket is dispensed with, and in which the stand is secured to the bench or the like f by screws which first of all pass through the holes o in the plate e^1; the projection l and slot l^1 are employed in this case, the plates c and e^1 being held together by means of the screw p, which also secures the spring n.

Figure 75 is a plan view of the same with the last removed. Figure 76 is a sectional view through the line X Y in figure 75. Figure 77 is a plan view of the base plate. Figure 78 is a side elevation

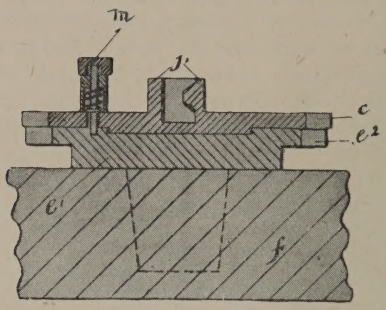


Fig. 76.

of the improved last support. Figure 79 is an underneath plan view of modified arrangement of base plate. Figure 80 is a side view of figure 79 partly in section.

The welting process also introduced to more general use the wooden last with the inserted tube and plated seat. To the use of the last-holding jack we owe also the greater use,

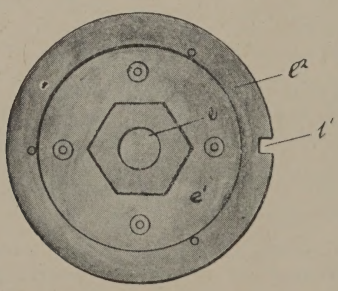


Fig. 77.

in Blake-sewn work, of lasts made mainly of wood, either with wooden tops and iron bottoms or, still more extensively now, of wooden lasts with plated bottoms. By the freer use of wood in the material of the last, a better form has been made possible, and we can now have a last for vertically-stitched work, that may be thin in the comb and

well formed at the seat, and yet which can be hammered upon without fracturing the last.

The speed demanded in the modern factory has exerted

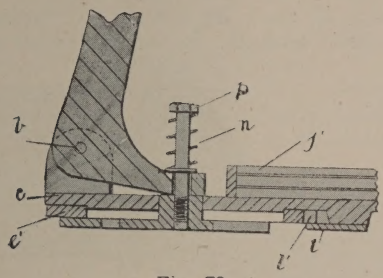


Fig. 78.

an influence upon the form, so that to-day the old form of last with a screw-fastened block is fast disappearing. What is now required is a last that, whilst it permits of the

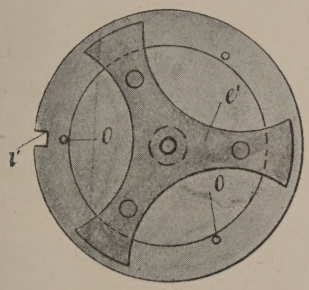


Fig. 79.

correct formation of the shoe itself (which the old thick-seated iron last did not do), shall also permit of easy withdrawal of the last from the constructed or partly-constructed shoe.

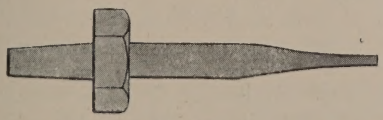


Fig. 80.

Just as one of the virtues of the welted method is the fewer times the last is withdrawn from the shoe in the processes of making, as compared with the McKay method, so the easier withdrawal of the last, tending less to damage

the workmanship already accomplished, is a distinct gain to a fine finish.

Thus a group of lasts known variously as "Easy Exit," or "broken lasts" and "sectional lasts," have become in use. The parts of some are key-locked, some self-locked, others are hinged, but nearly all are characterised by a new

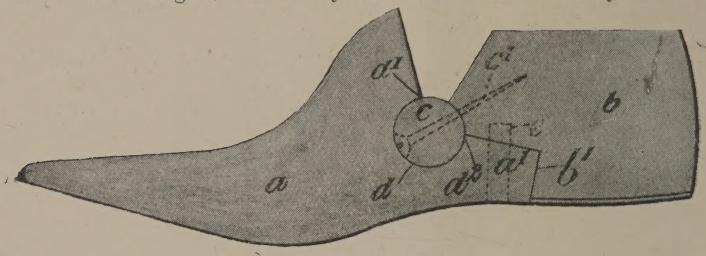


Fig. 81.

division of the last in a back and a front portion, instead of into a top and a bottom.

One of the earliest forms of lasts of this character is the well-known "Easy Exit" last of Messrs. Mobbs and Lewis. A later invention of this firm is the wedge-hinge last.

The Bostock and Miller patent is a good type of the broken last, and is illustrated in the following figures:—

Figure 81 is a side elevation of this form of last. A dowel pin e will be observed fixed to and forming a rear-

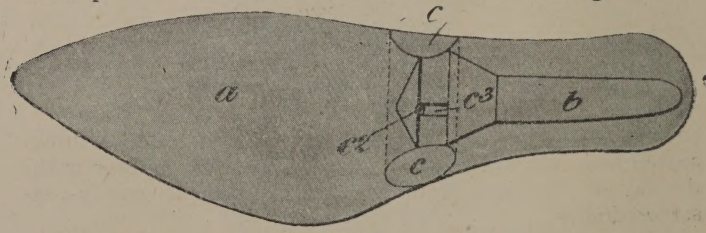


Fig. 82.

ward projection upon the front portion of the last. This dowel pin is adapted to fit the recess f, and is so fitted in relation to this recess that it will, as the hinge is closed, effectually prevent any accidental lift or rise of the heel portion of the last.

Figure 82 is a plan of a boot last embodying these improvements.

Figure 83 is a longitudinal part section of this boot last.

a and b are the two parts of the last, the former of which has a projection a^1 adapted to enter a corresponding recess or cavity b^1 in the other. These parts are hinged together by a block c secured by a screw c^1 to the part b, and engaging in a groove d in the part a.

c^2 is a screw or pin, and c^3 is an annular groove in the block to prevent the shifting in groove d.

e is the dowel pin by which the parts of the last are held together. This pin is secured in the projection a^1 of the last marked *e*, the upper surface of this projection being approximately radial to the hinge block c.

f is the aperture or recess into which the pin e is adapted to enter, this recess being formed in the part b of the last. The movement of the parts a and b being in a circular path having its centre at the hinge or joint, and the dowel pin

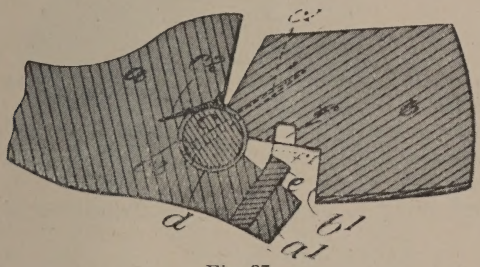


Fig. 83.

being inclined as described, it follows that, as the dowel pin enters the aperture, it will press upon that part of the edge thereof adjacent to the hinge or joint, first, with a gradually increasing pressure, so that the two parts of the last are drawn together at the hinge, and, second, with a gradually decreasing pressure. Thus, as the forward edge of the dowel pin travels along a circular path indicated by the dotted line f^1, it will bind tightly against the edge of the hole in entering it, but such forcing or binding action will cease when the pin is completely forced home into the aperture.

Mr. Brining's last is a further well-known example of this type. The object of the invention is to produce a last with its heel portion separated from its toe portion, yet so arranged that they are capable of being united and securely held together in position when in use. An irregular division line runs from the waist of the last, starting at the sole, and continued to the top of the last. In the two portions

of the last, and in the division line thereof, are arranged, as will be observed by figures 84 and 85, projections and recesses. That is to say, a projection is formed on, or let into, the toe portion, so arranged to pass into recesses formed for their reception in the heel portion of the divided last.

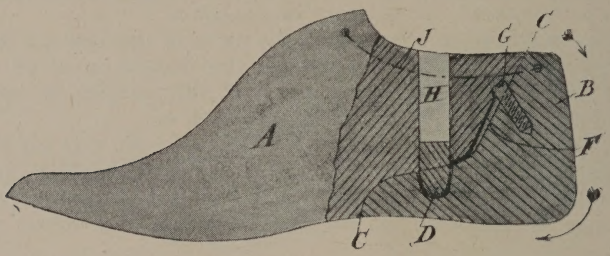


Fig. 84.

Figure 84 is a part sectional elevation of one form of Brining's last.

Figure 85 is a part sectional elevation of a last with two fixed projections, one of which is provided with a metal armature.

The first thing to be done in the formation of a set of

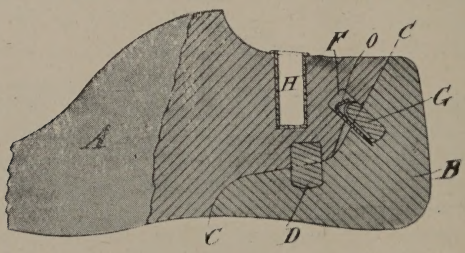


Fig. 85.

lasts is to determine the general character of the set by the construction of an initial model, formed according to the amount of spring, girth measurement, and sole width which are to characterise the whole set; and for the formation of this initial model the first process is the construction of the insole shape, or the form for the bottom of the last.

Assuming the formation of this model is to be entrusted to a last maker, a proper set of instructions to him ought to give the sole form, and the elevation showing the distance

from the ground (at the back) the seat should be for the particular heel to be carried; and also the amount of spring

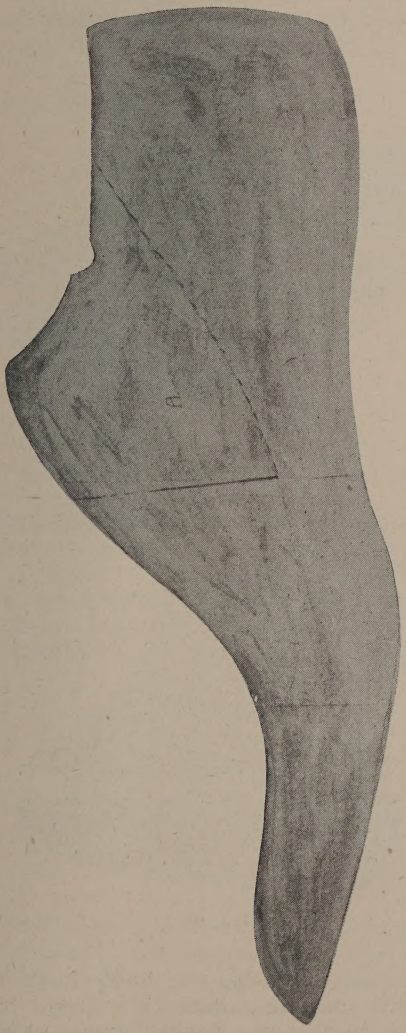


Fig. 86.

in the toe; the net girth measurements; the location of those measurements; the thickness of the outer side edge of the last, and of the inner side; and also a specification as

to the character of the bottom of the last, i.e., whether it is to be flat or convex. They should also state the character of toe end, whether stub, taper, or bevel.

These facts, in the main, can be conveyed by means of

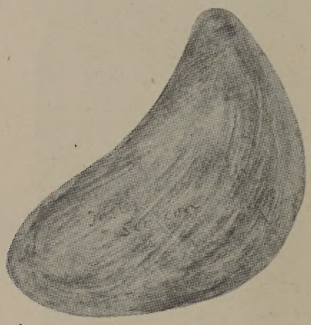


Fig. 87

drawings and patterns, and it is of these that we shall now treat, and afterwards of the actual processes for making lasts.

The instructions for the initial model have first to engage our attention.

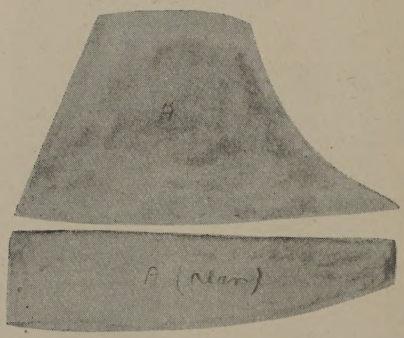


Fig. 88.

The method for preparing the insole form has already been dealt with, and the reader is referred back to the chapter dealing with "The Insole," where standard measurements are also given.

The spring and pitch would be shown on drawings such as are given at figures 86-90, and on these drawings would

also be shown the exact side measurements of the last; and then the other facts already stated as necessary would be recorded.

The remaining factor required is, of course, the girth measurements; and the discussion of these is the duty next before us.

The matter has been partially treated in Chapter IV.

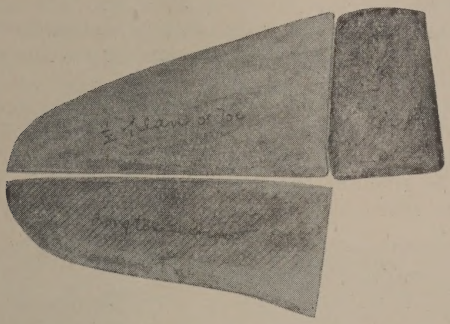


Fig. 89.

Therein it was shown that the usual English procedure is to add one-quarter of an inch between each full size for increase at girths at joint and instep, or a difference of one-eighth of an inch for the half-size, and that the usual Continental table is a replica as near as the expression in centimetres will permit of such a table of measurements.

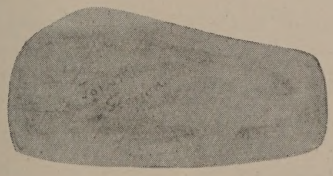


Fig. 90

It has already been said that different fittings practically represent different types of feet. The characteristics of these types have to be expressed in a "shape," as well as by measurements. The particular expression as to shape will be determined by the information already given concerning the characteristics of the feet of men, women, and children. Generally, the adult male form is, as to sole shape, from the fact of the more general excess of length of the great toe,

less even-sided than the female. The fact that in the female foot there is a more frequent excess of length in the second toe generally makes possible a more even-sided sole form (and, indeed, renders a pointed toe without excess of length possible). This is but to say that whilst the strict Meyer form is hardly ever wholly true for the adult foot, male or female, it is even less true for the female than for the male foot.

The curvature of the waist will be determined (by the type of foot and its girth measurement) upon the reasonings already fully treated of.

The factors which are determinative of the general character of the foot also determine the character of the measurements of the heel, ankle, and leg. (Tables of measurement will be given at the close of the book.)

Lasts are made either of iron or wood, or of a combination of these two materials. Iron lasts are likely to be less and less used.

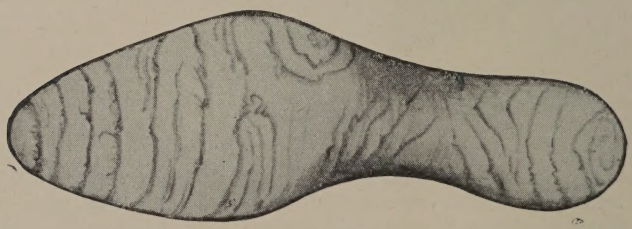


Fig. 91. Bark Bottom.

A large variety of timbers have been used for last manufacture, the principal sorts being beech, charme, hornbeam, maple, and sycamore.

Probably no wood is more used than that of the beech. The beech is indeed a wonderful tree, and its timber used for last-making is an example of how the highest things often serve the lowliest uses.

> Imperial Cæsar, dead and turned to clay,
> May stop a hole to keep the wind away.

One of the stateliest of our trees, its dimensions are rivalled only by the oak itself among the trees of Britain, and its smooth gray bark and beauty of outline are scarcely surpassed in loveliness even by that noble tree; it is a veritable wonder-store of possibilities for the service of man.

Good charcoal does it provide for him; stuffings for his bedding; and substance for his vinegar. It augments his

flour, and, under pressure, will yield oil for his use; and, even if these be not enough, our cocoa is made more by the friendly presence of the beech-mast. Its bark is sometimes used for tanning; but supremely from the shoeman's point of view the beech furnishes good timber for lasts.

Yet not all of the family are equally good for this final purpose. The slow-growing tree furnishes the best wood; and of this, the best is that of the boughs of young trees. It is most durable in a wet state, and so the French peasant loves nothing better for the protection of his feet than a beech sabot; and the millwright and the sluice-maker prefer this wood for their use to all others. And yet, however much beech be seasoned, it still ever longs for association with the watery element; and herein is it defective

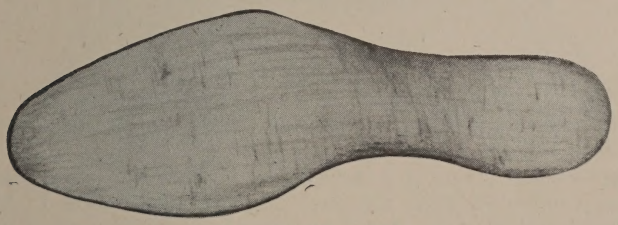


Fig. 92. Bark Side.

from the last-maker's point of view. So, the last made from beech must, for this reason, be kept in a warm, dry place.

To limit after-shrinkage, lasts made of beech are oft-times steamed. Always with a tendency to rot, and become worm-eaten when exposed to the open-air, this liability is re-established in beech lasts made of steamed wood or boiled wood left exposed in an open damp place. The steamed last is known by its pink colour. To be thus aware of these idiosyncrasies of the wood of the noble beech tree is to establish fit conditions for the storage and care of lasts made from this timber; and so let the boot manufacturer well note them.

The stem or trunk of the beech consists of a central pith and rings or zones of fibro-vascular bundles through which medullary rays radiate. In the growing tree the new wood forms next the bark, and is called sap-wood.* Gradual

* Those trees to which class the beech belongs are by several trade writers referred to as Exogens, from a false idea that these plants or trees grow from the outside. The term Exogenus, or Exogenous,

changes occur in these annual rings or layers of new wood as they become older, and in time (which varies from one to many years) they get hardened or solidified into ripe wood or heart wood.

A section of the stem would thus show in the central part

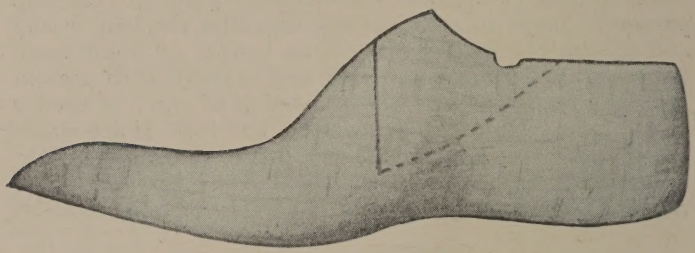


Fig. 93. Bark Bottom.

a core of pith. This is of no use to the last-maker. Next to this is the heart wood, and then the sap wood, and, outermost of all, the bark. The sap wood is less dense than the heart wood. From this fact of less density, and from other facts connected with the part the sap wood plays in the nutrition of the tree, it will be found that the sap wood will shrink more in the drying process than will the heart wood.

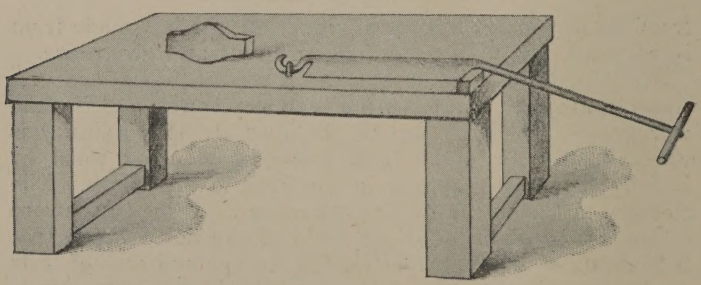


Fig. 94.

The shrinking and cracking is indeed greater and more marked as the circumference is reached.

From these facts it is quite obvious that, if a last were

plants, applied by Lindley to Dicotyledons to express this erroneous view of the difference in the mode of stem-thickening from that of the Monoctyledons, is now wholly disused by botanists.

cut from a piece of a tree as shown in the figure, the tendency of such a last would be continuously to decrease in width. Such a last produced in this manner is known technically as a bark bottom last. Bark sides will correspondingly shrink, if at all, in height.

The important thing is that the pair of lasts shall be produced from an equal direction in the wood.

Bark sides are preferred to bark bottoms. The usual practice is to produce triangular pieces of wood (as shown in figure 95) from the small trunks and boughs of trees. These trunks are sawn into lengths about a yard or more long. The lengths so produced are split into spokes, from

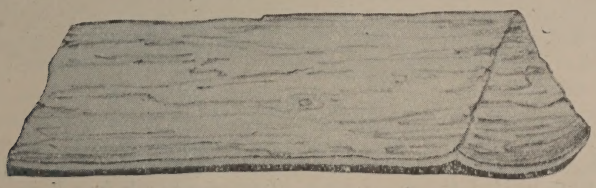


Fig. 95.

which three lasts are ultimately produced. The spokes have first been through whatever process of seasoning may be adopted.* From these seasoned spokes blocks are produced, approximately in shape to the last it is desired to make. These blocks are sorted into pairs; afterwards they are chopped or sawn into a shape such as is shown in figure 97.

The block is the first stage in the evolution of the last. It has now to undergo the process of knifing. Grasping the

* Deciduous trees should be felled in winter, as at that season they contain the least amount of natural sap. As soon as possible the logs should be stacked with packing pieces between them to allow the sap freely to evaporate. They should also be covered in from the weather and protected from direct sunshine. When the spokes are cut, in the first place, they should be laid horizontally, with fillets between, and allowed to remain in this position for six months completely protected from rain. Afterwards, for the same length of time, they should be placed on racks in a vertical position, and still kept apart. The seasoning can be hastened by steaming or boiling, or by placing in hot-air chambers. Natural seasoning is, however, by far the best.

block firmly in his left hand, and with equal firmness and vigour handling the bench-knife (shown in figure 94), the expert last-maker soon gives the desired form to the last. At this stage the proper pitch and spring are imparted; the width and shape of the forepart and seat are roughly indicated; and at the finish of the process of knifing, the roughed piece, as the result is now called, is placed in the

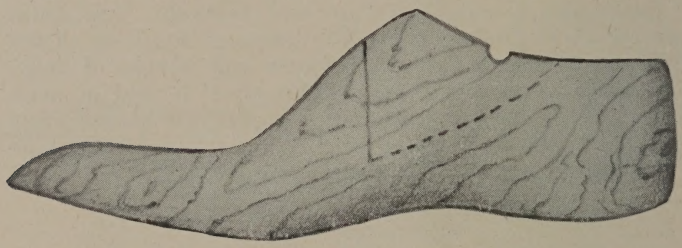


Fig. 96. Bark Side.

vice, and the block sawn down. Occasionally the roughed piece is knifed a second time after the block has been cut.

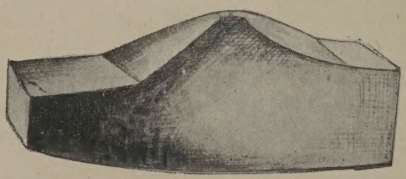


Fig. 97.

Then succeed the operations of rasping, scraping, hole-drilling, and finishing.

Chapter VII.

PRINCIPLES OF PATTERN-CUTTING.

There is a strongly established set of conditions in the shoe industry of to-day necessitating an increased degree of sub-division of labour. The less labour is sub-divided, the less is the degree of importance attaching to the scientific and artistic preparation of the fundamental patterns for boot construction. The greater and more minute this sub-division, the more imperative it becomes that the patterns determining the manufacture shall be scrupulously accurate. This is to establish the fitness of the various component parts of the boot or shoe for mutual welding, with such exactness as not to prove antagonistic to the co-working of the various machines concerned in the present-day industry.

With production on a limited scale and a lessened distribution, the labour of each worker must necessarily be of greater individual importance, and these conditions produce workers of greater individuality, if not of greater ability. Such a worker is enabled to meet difficulties which may occur through the deficiencies of former workers in the antecedent operations. Such difficulties it is impossible for the labourer in the modern factory to cope with, and it is not desirable that he should be compelled to attempt to do so.

Hence the importance of patterns so accurately designed for the whole of the processes, and of such scientific uniformity in their parts, that the occasions for delay and for the exercise of special technical ability in the operative processes shall, at any rate, be less frequent, if not altogether unnecessary.

Methods of pattern construction for uppers are both synthetical and analytical. Which of these contrary methods is correct is for our present reasoning to determine.

A true procedure in pattern construction, in some sort, includes both methods. This much may at once be said, that the first stage must give us a complete covering pattern for the last in one piece, and its component parts must afterwards be analysed from this first-obtained pattern, after referred to as the "standard." The methods of pattern construction which depend for the acquisition of this standard upon a synthetical method cannot be too stringently condemned. An example of such a method, frequent enough in the bespoke trade, is by cutting a Balmoral pattern, the quarter first, by fitting to the last, and next the vamp to the last, and has for its final stage the production of the standard by the union of these two component parts. These parts must, if the expeditious production of a true-fitting pattern is desired, be obtained by an analysis of a previously-obtained standard; and the production of this standard may itself (and preferably so) be obtained by the building up on a perfect-fitting "cover" pattern of the upper structure necessary when a pattern for any description of footwear other than a shoe is desired.

By a "cover pattern," or "forme," is meant a pattern which, when cut from leather and strained over the last, will fit that last and envelop it free and clear from wrinkles.

The construction of the upper portion of boot patterns can be conducted on a regular method from this cover pattern by rules to be formulated. It has first to be explained how this initial pattern may be made.

Many methods have been suggested for acquiring a correct covering form. The diversity of the methods may be understood when it is said that the suggestions range from one requiring the construction of a rough basil upper lasted on to an insole (tacked upon the last to be fitted). This upper so tacked over and approximately fitting the last is thoroughly wetted. It is next placed, in this wet state, before a fire, and the upper is then shrunk down to the last. The cover pattern is obtained by cutting the shrunk basil form into a half section. A more primitive method is to wet and stretch tissue paper over the last itself, and then cut off to a line representing the centre of the last on its front and back curves, and to the sole edge along the bottom.

Before one can legitimately acquiesce in such methods, the question needs to be determined whether a flat form obtained by the delineation on a sheet of paper of a half-

section of a blocked rounded form can ever be a true one. The rounded form was obtained by the previous stretching and straining of a flat form upon a rounded one. In some parts its fibres have been stretched, and in other parts its edges have been notched or cut to render the fit complete. In order that any flat surface may fit a rounded one, whatever the shapes of the flat piece and of the round piece, a repetition of this process in some degree is bound to take place. A flat pattern obtained by the delineation of a half-section of such a strained covering is not necessarily the form that would render this stretching and straining under the process of lasting most easy of accomplishment. Certain deductions at some parts and additions at other parts of a pattern so obtained would be necessary to secure

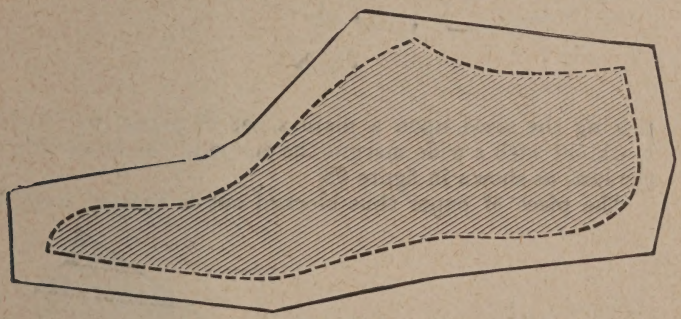


Fig. 98.

a clean-fitting upper, and hence the literal adhesion to the profile line of half-section of a blocked pattern is a fault, and not a virtue.

At the very best, this cover pattern can only resemble the shape of the last. It is almost impossible that a flat pattern can ever do more than approximate to the curvilinear form of the last.

The plan of producing upper patterns from a "form" or "cover pattern," was first suggested in an American work on pattern-cutting by Mr. Soule. It was brought to the notice of the English section of the trade through a competition instituted by a trade journal, in which competition the late Mr. T. J. Brophy, of Dublin, was the successful competitor. The method was afterwards popularised by Mr. Brophy in his "Pattern Cutting Made Easy."

Since the first publication of the method, however, reasons have been found, some of which have already been

stated, for dissenting from the results given under the plan of procedure as explained by Mr. Soule.

In cutting "forms" it is usual to take the left last, and,

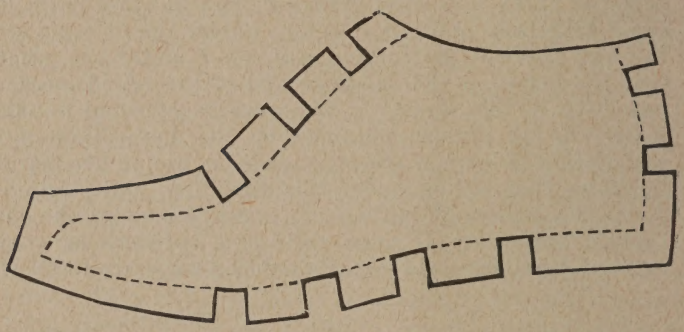


Fig. 99.

placing the same upon a plain sheet of paper, to roughly block out with a wide margin the shape of the outer side of the last, as shown in figure 98.

The piece of paper thus blocked out is treated next, by

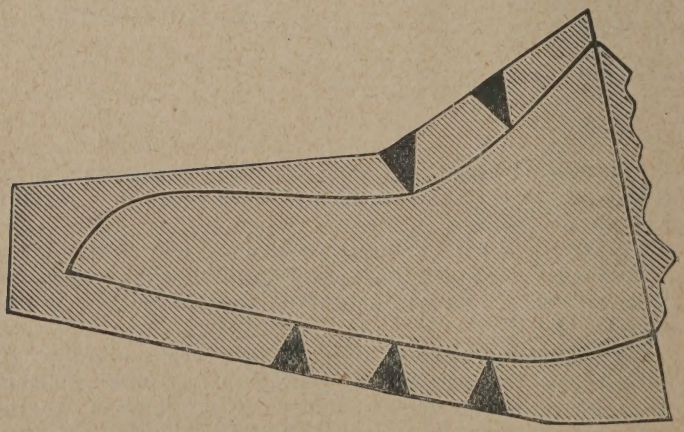


Fig 100.

making cuts or slits all around its border, as shown in figure 99.

Sometimes these cuts are made in square and sometimes in V-shaped form.

The last to be fitted has now to be marked down the front centre and at the back. It is also desirable to mark certain other points. Thus:—

(a) The position of the joint girth at two-thirds the length of the last measured from the back;

(b) The position of the instep at one-half the length of the last measured from the back;*

(c) The counterpoint, i.e., the point of greater length on the back of the last.

These markings are shown on figure 101.

The form obtained by the process as shown in figure 99 is corrected by measurements obtained from the points a, b,

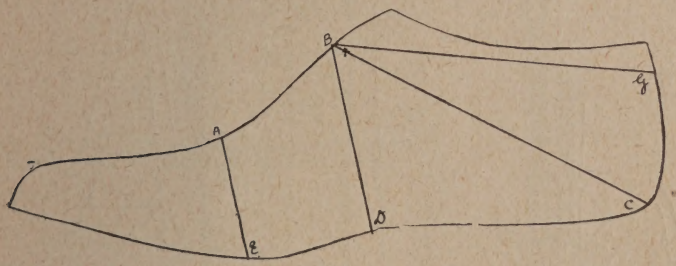


Fig 101.

c, d, e, and f and g. The resulting form will be a net form as shown in figure 98.

The form, however, may be obtained, and, if necessary, graded by a special machine now to be illustrated and described.

Tourigne's pattern-making machine is an ingenious machine for the accurate laying out of a pattern for enveloping a curvilinear form.

It consists in the employment of a string, cord, or other flexible line, so mounted and guided and centred that one end may be made to follow the outline of the body while lying upon and moving over in perfect parallelism with its curvilinear surface, and its other end may receive motion from the first end to register or indicate its movements, thus delineating them both in outline and measurement, and forming a surface-covering pattern.

Figure 102 is an elevation of the machine, and figure 103 is a plan of the same.

*The grades for these positions are respectively 1-9 and 1-6 of an inch.

A is a pedestal here shown as of T shape. Around the lower portion of its stem is fitted an eye or sleeve, b, of an arm, B This sleeve is a split one, and is fixed to its position by impinging lugs b^1, which are tightened by a bolt and nut, b^2, whereby the sleeve may be tightened upon the step of the pedestal, or may be slackened for the purpose of allowing arm B to have an oscillatory movement thereon.

In the end of the arm B is fitted a holder, C. having a downwardly extending stem, c, which passes through a

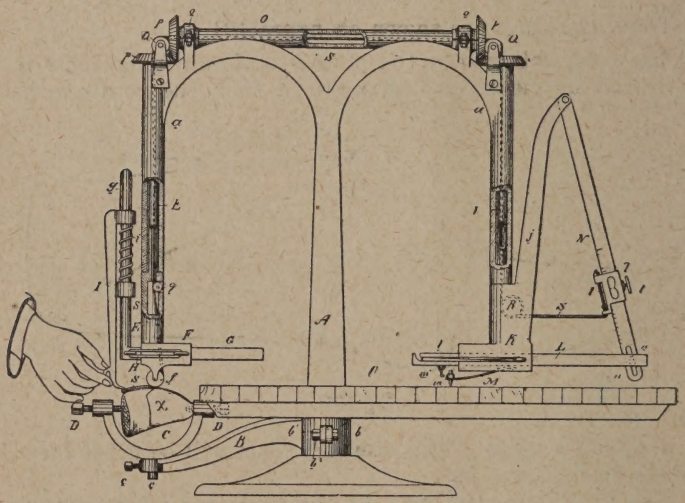


Fig. 102.

socket in the end of the arm B, and is set by a screw, c^1, whereby this holder may be adjusted in a position vertically, and may also have a rotary movement upon its stem c.

In the ends of the holder C are fitted screws, D, acting as centres or holders for the last, X. The depending arms, a, of the pedestal are made tubular, and through the left-hand arm extends a hollow shaft or tube, E, which, where it emerges from the hollow arm, is increased in diameter only for the sake of appearance. To the lower end of the shaft E is fixed a block, F, in the lower portion of which is mounted a guide pulley or roller, f. A square opening is made longitudinally through the block F, and receives a bar, G, one arm of which is horizontal, and the other arm, g, extends upwardly at right angles. A spring, H, here shown as a rubber strap, is secured to the block F and to

the end of the bar G, and serves to keep the bar to its exact position in the socket.

Fitted loosely, or pivoted upon the upright arm g is a handle, I, which is influenced by a spring, i, secured to the upright arm, and having a tendency to keep the handle up. The other arm, a, of the pedestal is also made hollow, and has extending down through it a hollow shaft, J, the lower end of which carries a block, K. This block has a longitudinal aperture through which fits a lever, L, which

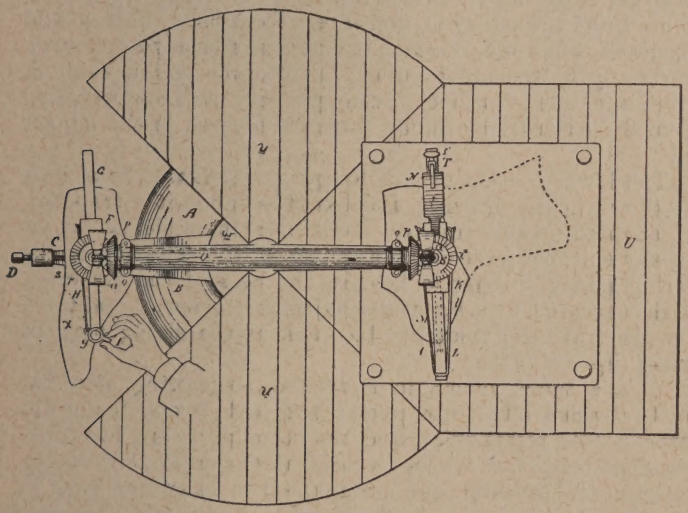


Fig. 103.

is held to its position by a spring-strap, l, secured to the block and bar.

Secured to the bar, and projecting through a slot in the bottom of the block K, is a spring arm, M, in the end of which is fitted a pencil, m. A hook, m^1, provides for hanging up the pencil when desired.

The lower portion of the shaft J is provided with an upwardly extending diverging arm, j, to the top of which is pivoted a hanger, N, the lower end of which is slotted at n, and receives a pin or stud, n^1, from the bar L, whereby a connection between the bar and the hanger is formed.

Upon the top of the pedestal, in boxes, o, is mounted a hollow shaft, O, on each end of which is a bevelled gear, P, meshing with a bevelled gear, p, on the tops of the shafts E J.

In the shaft E, near its bottom, is a guide pulley, q, and on the top of the arms a of the pedestal are guide-pulleys, Q. Near the bottom of the shaft J is a large guide-pulley, R.

S is a string or cord, made of any suitable material of flexible nature. One end of this cord is attached to the bottom of the handle I, and then passes around pulley f, up through a hole in the block F, and into the hollow shaft E, in which it is guided upwards by the pulley q until it emerges from the tip of the shaft. It is then guided horizontally by the pulley Q, and enters the hollow shaft O, and from the other end of which it emerges, and is guided down vertically by the other pulley, Q, into the hollow shaft J, from the side of which it emerges near its bottom, being guided outwardly by pulley R, and is secured to the hanger N.

The lower portion of this hanger is graduated to a scale as shown in the drawing, and has fitted upon it a traveller, T, adapted to slide up and down over the scale, to be set in any suitable position by a set-screw, t1. The end of the string passes through a hole in the base of the traveller, and is secured to a vertically-adjustable screw, t, mounted on the traveller, whereby the slack of the string may be taken up.

U is a table, shown in figure 103, consisting of a flat plate divided into three parts; one part or end being approximately rectangular, and the other parts are two independent sectors, u, which are centrally pivoted at w on the stem of the pedestal, and are adapted to be turned back to the position shown in the figure, wherein they join the rectangular portion; or to be turned forward to meet together to form a table in front.

Having described the details of the mechanism of this interesting machine, let it be now shown how it is operated. The last is set in any position that may be desired to obtain measurement from any desired centre. It has an oscillatory adjustment by reason of the pivoted arm B moving on the stem of the pedestal as a centre; an oscillatory adjustment of the holder C, on its own stem c; and there is a vertical adjustment of the holder in its socket in the arm B. By these various adjustments the last may readily be turned to any position under the roller f, which will give whatever centre for measurement may be desired, and especially by the vertical adjustment it can be brought most directly under the roller. When the last has been properly adjusted for one set of measurements, the handle I is grasped

as shown, and by its downward movement the string may be brought down to lie flat upon and over the curvilinear surface of the last; then, by the movement of the hand, the end of the pivoted handle, and, consequently, the end of the

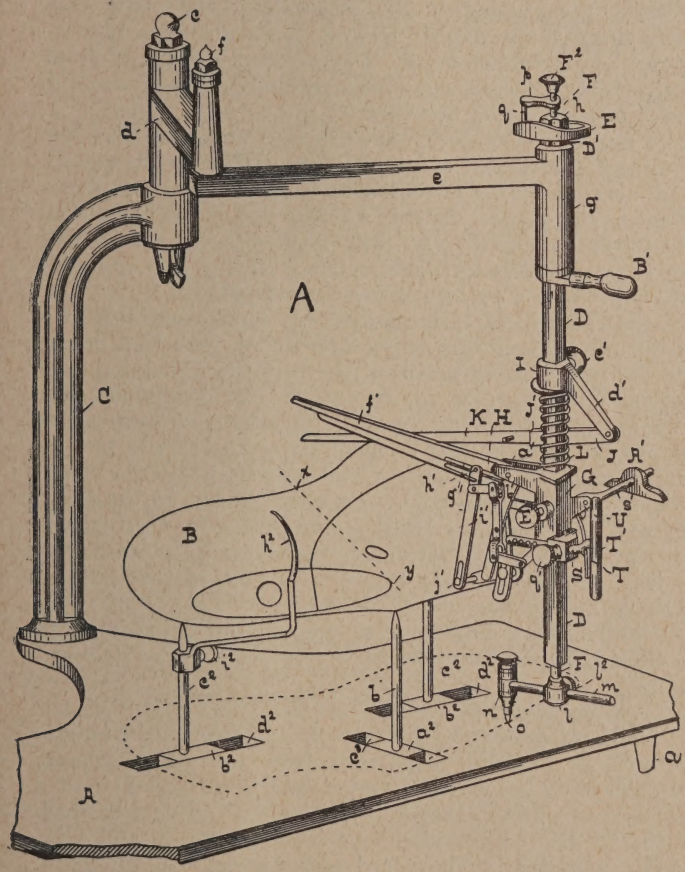


Fig. 104.

string, may be made to follow the outline of the last, while that portion of the string between the handle and the roller fits perfectly the contour of the curvilinear surface. The movement in pursuance of the outline is possible by reason of the ability of the bar G to turn with the shaft E as

centre, and the handle I to turn on its own centre, giving thus the course of the outline; whilst the longitudinal movement possessed by the bar G enables the operator to pull the handle horizontally, whereby the string is caused to follow the outline of the last, whilst the other end, acting through the hanger N, and the longitudinally-moving bar L, causes the pencil to move over a sheet of stout paper, giving thereon not alone the outline, but also the correct measurements upon it.

The result is, therefore, that the measurements over the curvilinear surface of the last are transmitted to the pencil, which accurately lays off equal measurements on the plane surface of the paper. In this way the pattern is delineated of the exact dimensions, so that when it is cut out it will accurately fit the curvilinear surface of the last, and, in fact, to produce a perfect form or cover pattern.

As indicated in the first part of this description, it is also possible to grade forms larger or smaller from the initial last. This is done by means of the traveller T moving over the graduated scale of the hanger N. It is obvious that by moving the traveller upward, the nearer it approaches the pivotal axis of the hanger, the greater will be the movement of the lower end of said hanger, by reason of the same movement of the string communicated from the other side, and thus the pencil will record greater measurements than indicated by the string on the other side enveloping the last. By moving the traveller downwards the reverse result is accomplished.

Cover patterns may be mechanically produced also by the Goodrich measuring device, and as well by the Baynard machine.

In the chapter on "Measurements," the method of use of Goodrich's appliance has been fully illustrated and explained. In drafting a pattern from the measurements thus obtained, the pattern maker will be provided with a scale corresponding exactly to the scale a^2 there described. He should also be provided with a swinging arm and scale slidably mounted on the board corresponding to the figure 39 (Chap IV., et seq.).

The measurements recorded from the scales a^2 and d^2 represent horizontal and vertical measurements from the vertical projection of the line of intersection of the surface of the base and face of the heel-rest, so that the pattern-maker is thereby enabled to plot a curve which will correspond exactly to the front contour or profile of the foot in its exact relation to the back of the heel and the

bottom of the foot. This contour-line determines the front edges of the quarter-patterns and the middle line of the

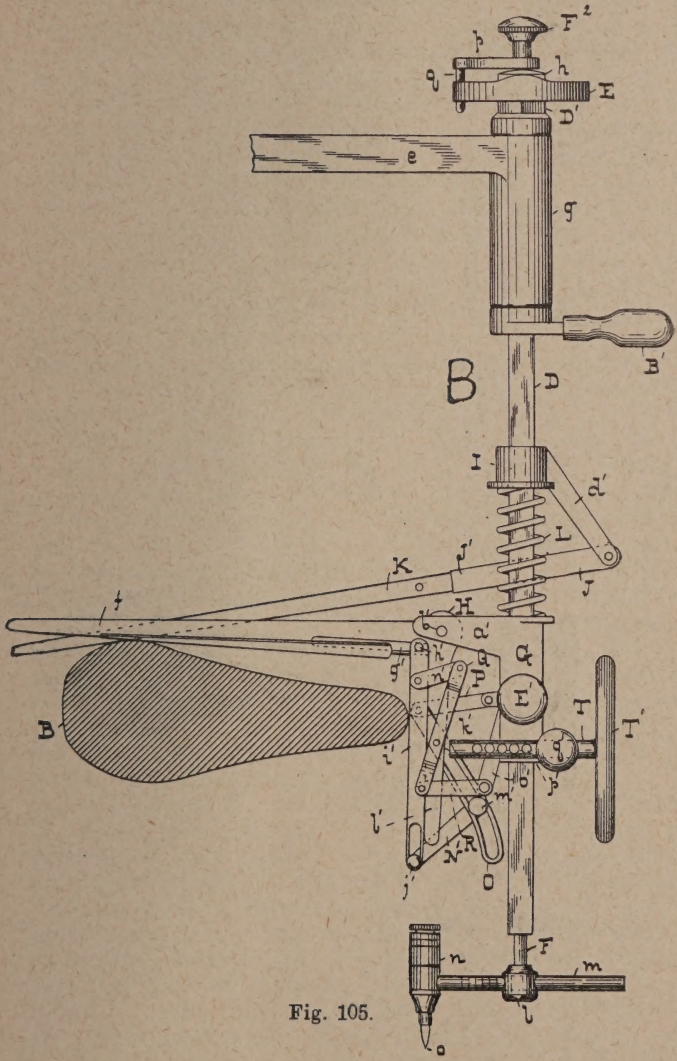


Fig. 105.

vamp-patterns. The widths of the quarters, vamps, etc., are then ascertained by taking the tape measurements at

the points on said contour-line corresponding to the points on the foot at which such measurements were made to the

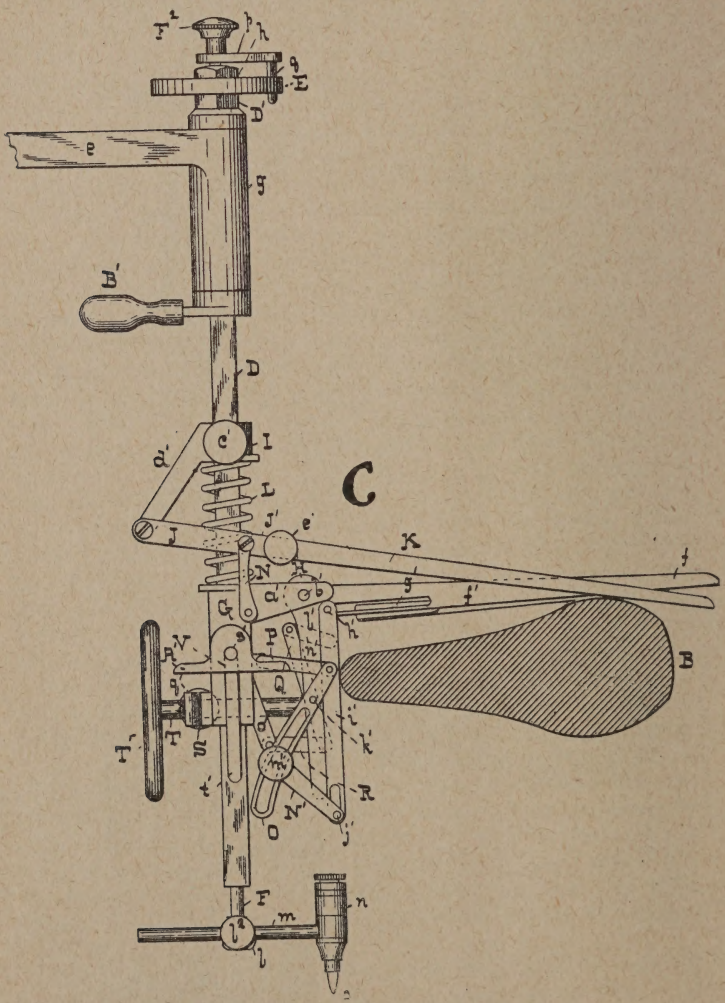


Fig. 106.

opposite edges of the pattern, the desired fulness at the various points thus being accurately provided for.

A scale d^3 on the scale-plate d is employed to measure the inclination of the bottom of a last.

The Baynard machine for describing shoe patterns from lasts next demands attention.

Figure 104 is a perspective view of the machine with certain parts of the base thereof broken away.

Figure 105 is a front view of certain parts of the machine illustrating the first step in the operation of describing a pattern. Figure 106 is a reverse or rear view of figure 105. Figure 107 is a similar view to figure 105, except that the moving parts of the machine have different relative positions, or occupy the relative positions indicated in the perspective view of figure 104. Figure 108 is a view of the same parts as are shown in figures 105, 106, and 107, but they are seen from a point 90 degrees removed from that used in the former figures. Figure 109 is an underside view of the machine, and figure 110 is a similar view with a certain covering plate remover. The remaining figures are details of the invention.

Referring to the drawings, A is the base plate of the machine, supported by the legs, a. B is the shoe last to be operated upon, and it is sustained at a low elevation above the base plate by means of three pointed pins of differing lengths passing through it. By these means the last is held in a perfectly horizontal position. The upper or overhanging end of the standard, C, is bored out and fitted with a stationary stud, c, and to this stud is attached the first of the swinging arms, d. The second swinging arm, e, is pivoted to the first by means of the stud, f. At the outer end of the swinging arm e is a socket, g, adapted to turn circumferentially the bar D. It will be seen by figure 111 that the portion of the bar D within the socket g is circular, whilst the portion below the socket is square.

E is a circular plate secured to the upper end of the bar D. F is a rod extending entirely through the bar D, and adapted to turn therein. The bearings for the rod are shown in figure 111, and it will be seen there is a spring, i, confined endwise between a collar, j, on the rod and the upper bearing, k, which serves to keep this rod feeding at its lowest position. The lower end of the bar F has a block, into which is fitted a pencil-holder and pencil, as shown. At the upper end of the bar F is a small arm, p, carrying a downwardly extending pin, q, adapted to enter any one of the four holes, r, s, t, and u (see top of figure 107 and diagram figure 112), for purposes to be described.

G is a block adapted to slide vertically on the bar D,

having a bracket, a^1, in which is pivoted the bent lever, H, at b^1 (figure 105). I is a collar fastened by a set-screw to

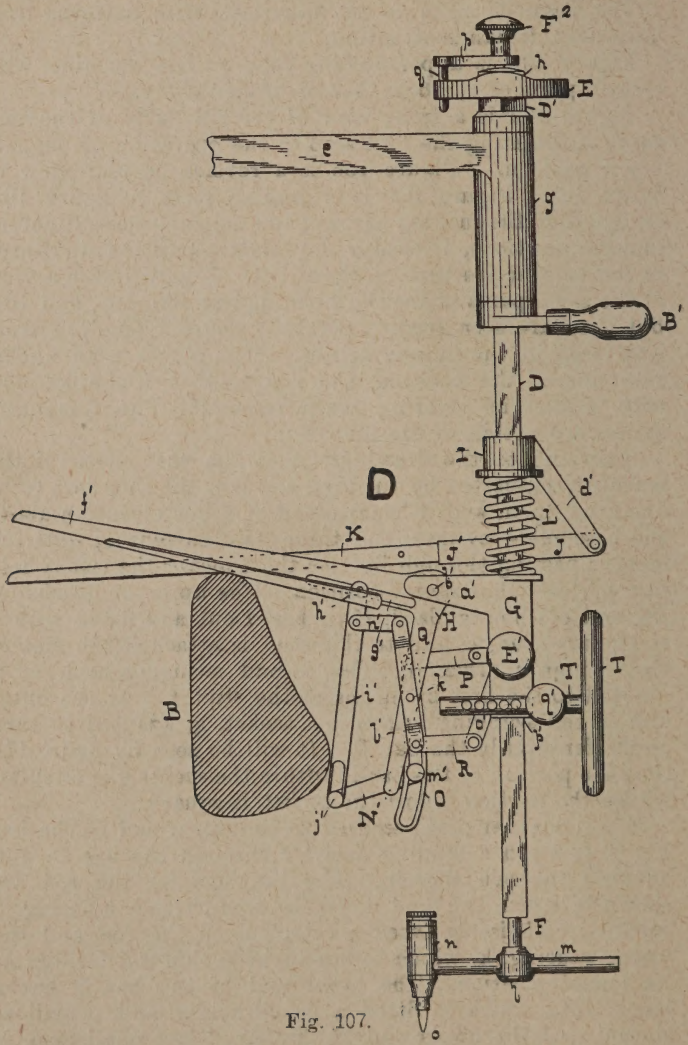


Fig. 107.

the arm D, having a bracket a^1 in which is pivoted a lever, J, having at one end a socket, j^1, adapted to receive an arm, K.

From the construction described, it will be seen that if the outer end of the arm K is lifted, the block G will be

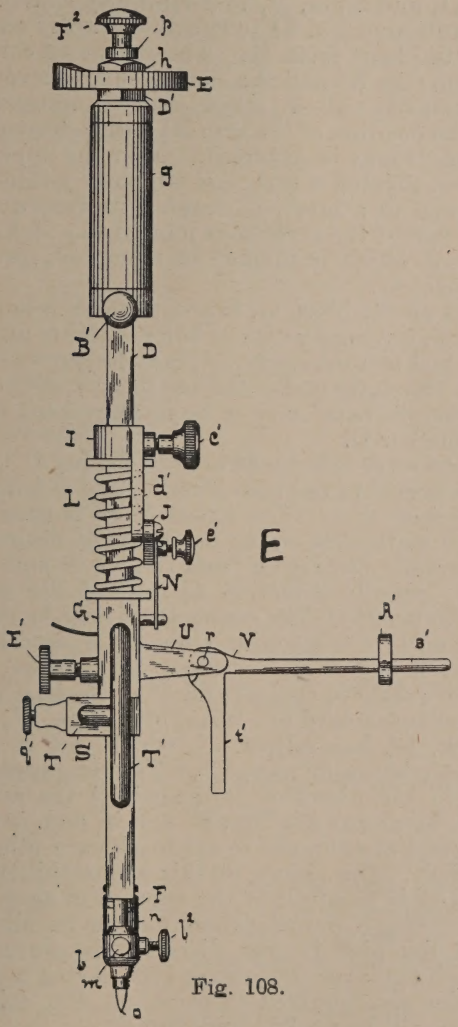


Fig. 108.

raised on the rod D, and the spiral spring, L, will be compressed.

The horizontal arm, f^1 (figure 107) of the bent lever H is flanged to increase its width, and has a slot, g^1, in

which slides a pin, h^1, in the branched end of a a bar, i^1. The lower end of this bar i^1 is slotted and connected by an arm, N^1, and a pin, j^1, to a vibratory slotted curved lever, O, fulcrumed at k^1 to the downwardly extending arm l^1 of the bent lever H. The means of connection between the arm N^1 and the slotted curved lever O consists principally of a screw and thumb-nut, m^1, whereby the position of the arm N^1 with reference to the slotted lever O may be adjusted. Near the upper end of the bar i^1 is pivoted a link, n^1, which is jointed to the vibratory end of a lever, Q, having its fulcrum at k^1. The lower end of the lever Q is jointed to a link, R, the other end of which is pivoted to a lug, o^1, projecting from the block G.

S is a lug on the block G, through which is adapted to slide a bar T, having a series of holes, p^1, into any one of which the end of a set-screw, q^1, may be screwed to hold this bar. The outer end of the bar has a cross-head, T^1, which is thrown back so as to be in alignment with the centre of the bar D.

V is a bent lever fulcrumed at r^1 in the lug U. A^1 is a foot on the arm s^1 of the bent lever V, and t^1 is the other arm of the said lever. The set-screw E^1 is used to hold the block G stationary on the bar D, when desired.

B^1 is a handle projecting from the bar D and extending in an opposite direction to that of the lever K, whereby the bar D and its connections may be moved in the operation of the machine hereinafter described.

The pins b and c^2 are screwed into blocks a^2 and b^2 adapted to slide in slots c^3 and d^2 in the base plate A. The block a^2 is fastened to a triangular plate, C^1, and the other block, b^2, has rollers, e^2, which rest in angular slots in the triangular plate C^1. This triangular plate is moved in the direction indicated by the arrows in figure 110, by means of a lug, f^2, and in such movement the pins b and c^2 are made to approach each other, or to be distended. The object of this adjustability of the pins b and c^2 is to admit of the support of shoe lasts of any size. When the adjustment is made, all further motion of the pins in any direction is prevented by means of a hand lever, D^2, figure 109, having a cam, g^2, on its under side adapted to press on the triangular plate C^1, as will be readily understood.

To prevent the seated lasts from being lifted, one of the pins, c^2, has an adjustable hook, h^2, the point of which may be made to engage with the top of the last. The adjustment is made by means of a set-screw, i^2.

Now let us see how the pattern is produced by this mechanism.

Supposing that a last is seated on the pins b and c^2, and held down by the hook h^2, as shown in figure 104, and it is desired to describe on a paper which has been previously placed over the pins and smoothed down to the base plate, a pattern from which one-half of the upper may be cut, the operation is as follows:—

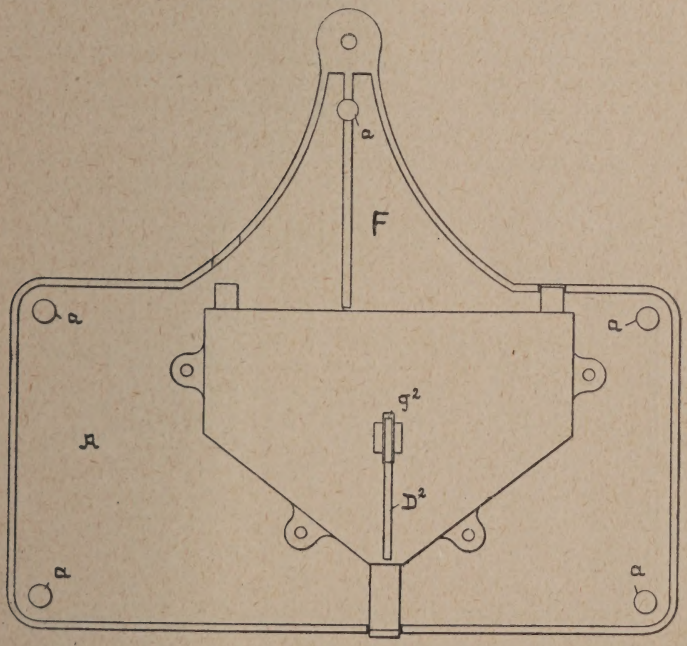


Fig. 109.

The collar I, which carries all the levers and other mechanism attached to the block G, is adjusted in height on the bar D, until the arm H, when in a practically horizontal position, will touch the shoe last at the point x on the dotted line in figure 104, and at the bar il touch the said last at the point y on the same dotted line. The rod F, which has been supported in an elevated position by the pin q resting in the shallow hole us which is in the elevated part of the rim of the plate E, is now lifted by the knob F2, and the pin q allowed to enter the hole r, which has the

effect of bringing the pencil end of the bar m in alignment with the arm f1 of the lever H, and at the same time permit the point o of the pencil to touch the paper on the plate A. This gives the starting point of the first line to be described, or the beginning of the first pattern-describing operation. Figure 105 shows the relative positions of the last and the various parts of the invention at this time. The operator now grasps the handle B1 and pushes the movable mechan-

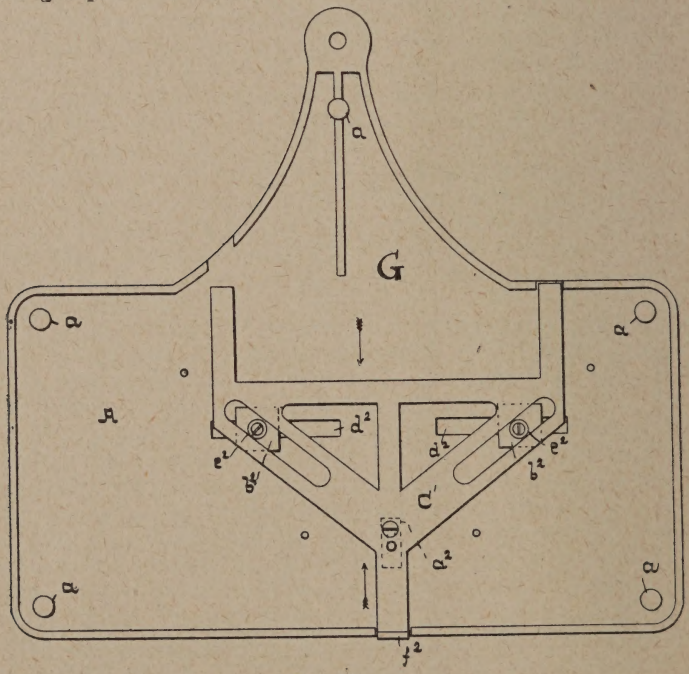


Fig. 110.

ism toward the toe of the shoe last, keeping the arm f1 of the lever H at a right angle with the longitudinal line of the shoe last. Now, supposing, for a moment, that, instead of a shoe last, a block of uniform size and shape throughout its length was on the pins projecting from the base plate, the line described by the pencil in passing from one end of the block to the other would be straight, and parallel with the block. But in a shoe last, the shape being irregular, a curved line is drawn. It will be seen that if the bar i1 is held motionless, and the arm f1 raised, the pencil point

o will be forced out or from the last. But if the said bar is not held, the raising of the arm f^1 has no effect on the position of the pencil point o.

In following the contour of the shoe last, the raising of the arm f^1 as it approaches the ball of the shoe last has a tendency to draw in the bar i^1, but as that bar cannot move in past the surface of the shoe last with which it is in contact, the whole moveable mechanism is moved out. In other words, the curved line which would be described by the pencil as the bar follows the shape of the instep and ball, if the arm f^1 were not employed, is modified or distorted when that device is used, and the line produced is a compromised one, resulting from the modifying influence which the arm f^1 has on the bar i^1, or vice versa. This part of the operation is continued until the bar i^1 passes to the toe of the last.

CHAPTER VIII.

PRINCIPLES OF PATTERN-CUTTING—*Continued.*

To prepare the machine for the second part of the operation, which consists in describing the edge of the pattern which is to be turned in or under the sole, the bar T is drawn outward from its normal position shown in the drawings, a distance equal to the width of the turned-in portion, and secured by the set-screw q^1. The knob F^2 is now raised to admit of the pin q being inserted in the hole t in the rim of the plate E. This brings the pencil bar under the bar 7. The moveable portion of the machine is now moved, so as to bring the cross head of the bar T in contact with the bottom of the shoe last. The head of the bar T is now moved along the bottom of the shoe last from the toe to the heel, or vice versa, the bar T being kept at a right angle with the longitudinal line of the last, and the turned-in edge of the pattern is thus described.

To prepare the machine to describe the heel-line, the bent lever V is brought in contact with the heel part of the last, and carried along it in either direction, the shoe A^1 on the arm s^1 bearing on the surface of the shoe last and the arm t^1 of the lever bearing against the extreme end of the heel. This concludes the pattern-describing operation.

By reference to figures 104, 105, 106, and 107, it will be seen that the arm K rests on the shoe last in advance of the arm f^1 of the lever H. This arm K operates directly through the medium of the link N to raise and lower the block G, and when used in connection with the arm f^1 it serves to modify the effect of the position of the arm f^1 and the position of the pencil point. In other words, the elevation of the arm K serves to draw in the pencil point, and its depression serves to throw the said point out, or farther

from the centre line of the last, provided the arm f1 is held stationary.

To this form, produced by hand, and sometimes by ma-

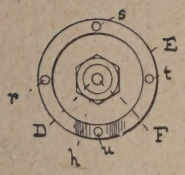


Fig. 111.

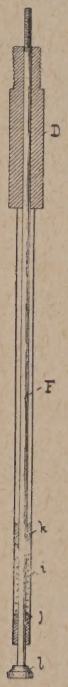


Fig. 112

chine, certain allowances have to be made according to the process of manufacture and nature of the material of which the boot or shoe is to be made.

Hand-stitched work requires less lasting allowance than Blake-sewn work; machine-welted more than hand-welted; machine-lasted more than hand-lasted. Stated generally, machine processes demand greater allowances than manual processes. The economics of manufacture demand that these factors should be regarded in estimating relative costs of different methods of manufacture (see also page 158).

The average allowances are as follow:—

Handsewn.	Machine-sewn.	Welted.
Men's, $\frac{3}{8}$ ...	Men's, $\frac{5}{8}$ ...	Men's, $\frac{1}{4}$
Women's, $\frac{1}{4}$	Women's, $\frac{1}{2}$ ...	Women's, $\frac{1}{4}$
Children's, 3-16 ...	Children's $\frac{1}{4}$ ...	Children's, $\frac{1}{4}$

These allowances may also be arrived at by the use of a scale, as Damer measure (Chap. IV., quod vide).

The principle upon which all boots are fitted is not so much that they are to be the same size as the foot (within narrow limitations this is, of course, necessary); it is rather that they shall be a corresponding form in the finished boot to that of the foot it is supposed to fit

If this fact be admitted, the futility of struggling with fractions like the 288th part of an inch, or even of the

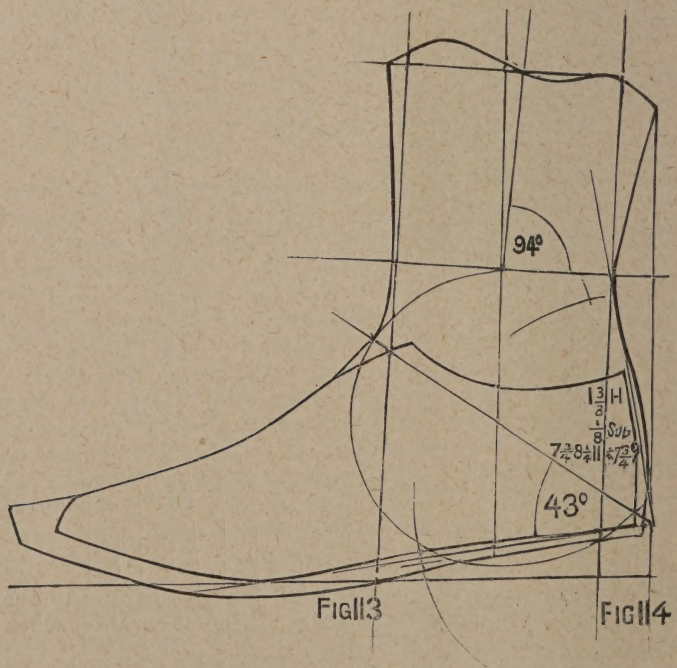


FIG 113 FIG 114

64th of an inch, in this connection may be plainly seen. We are far from alleging that the mention of such fractions may not be necessary in an academic discussion upon scaling and grading; but there can be no place in workshop practice for the use of such fractions, simply because the shoe artisan has no tools capable of dealing with such finely-spun quantities. Shoe manufacture is quite complicated enough, without the unnecessary introduction of the vernier and the micrometer screw.

That system, then, which will produce for us a pattern

with a superstructure, evolved from this cover pattern, of the most correct resemblance to the form of the human ankle and leg is for us the most successful and the best.

The correct form of the foot portion being guaranteed for us by the correct shape of the last, the leg and ankle correctly dealt with, should result in a perfect-fitting boot.

The principles regulating this construction of the upper portion are those involved in a discussion of the subjects (or, rather, group of subjects) referred to as "pitch" and "inclination." About these two terms there is frequent confusion. Presuming lines perpendicular to the ground

Fig. 115.

line traversing the front and back of the pattern, and having its front line and back line tangent to such perpendicular lines, the deflection of the front line from the perpendicular is spoken of as "pitch"; the deflection from the back line is referred to as "inclination."

A pattern may, therefore, be "pitched" forward and "inclined" backward. With a very large leg measurement this has frequently to be done. "Pitch" has relation to the position given by the raising of the heel. "Inclination" is largely controlled by the leg dimension and the smallness of the heel in relation to the width of the leg and ankle. Any theory of pattern formation denying the essential difference between pitch and inclination, and limiting

the alteration of the form only to the amount by which the heel is raised, is in a dilemma when a problem involving a large leg dimension, small heel girth, and a low heel height, has to be dealt with.

A low heel requires a pitch approximating to the perpendicular position, whereas a large leg measure accompanied by a small heel measure necessitates a backward "inclination" of the pattern.

Alteration in the pitch of patterns is occasioned by any

Fig. 116.

factor causing an alteration in the hinge joint at the ankle. Where the leg articulates with the foot, a double hinge joint is formed. The widest angle formed by the opening of the hinge is in the front, above the instep, at the juncture of the foot with the leg.

The flesh and skin covering the bones being elastic and adaptable in its nature, gives readily and permits of free motion in this joint. In any event, the effect of the opening of this hinge joint is to stretch the outer covering into a less curved, and, hence, a straighter line. There would be a compensatory alteration in the back curve of the foot

above the heel bone, causing the integument there to assume a more acutely-curved form. Thus, if the opening of the hinge joint indicated an angle of, say, ten degrees in the foot at the front, the higher part of the curve at the back would be depressed correspondingly.

The alteration in the relation of the foot and leg made by the opening of the hinge joint of the ankle is shown in the two figures, Nos. 115 and 116.

Seeing, therefore, that the alteration in the form is occasioned by an alteration arising from the ankle joint, it seems clear that the method for the determination of the pitch of the pattern should be arrived at by a calculation made from a central point given by the ankle joint itself.

In order that we may be clear as to the effect upon pattern-cutting caused by alteration in the height of the heel, let us observe the phenomena of the foot and leg associated with the raising of the heel from the ground.

Whilst the foot is in the plantigrade position, the front line of the leg is, in its lowest portion,* practically perpendicular to the ground.

As the foot is raised to the tip-toe position, the hinge joint at the ankle makes a straighter line in the juncture of the foot and leg. At the same time, the leg position is spatially more forward. The curve at the point just above the heel bone at the back is more acute.

To whatever height the heel be raised, practically, it will be found the perpendicular position of the front line of the leg is constant in its relation to the ground line.

Whilst this is so, however, the leg position is for every half-inch the heel is raised spatially a corresponding amount more forward.

Confusion is very often occasioned in the views taken on this matter by the appearance of the finished standard; and wrong deductions as to the actual practice of pattern designing are frequently made on this account.

Thus it is frequently said that for a last with a big rise from joint to instep, or with a bold outside joint sweep, the pitch of the pattern must be more backward; when in reality what is meant is that the pattern for a last under these conditions will, when laid out flat, have the appear-

*To about six and one-half inches from the ground. After that distance is reached, the front of the leg being slightly concave, the line of the leg is a little in front of a perpendicular line.

ance of being cut more backward, even if it be designed upon the perpendicular basis.

There is a necessity, however, generally that patterns as to the front line of the leg shall have a deflection backwards (especially in seven-inch patterns) from a line passing perpendicularly from the ground through the front boundary of the half-ankle measure.

This is necessary for the "life" of the pattern. In fact, this difference in the position of the leg of the pattern from that of the leg itself constitutes the "draft" of this portion of the pattern. Just as goloshes are raised and pulled down in order that they may "clip" the foot, just for this same reason is it necessary in the top portion of the upper to make a difference in the initial form for an after effect to be obtained through this means.

An excessive width of the leg makes a difference in the "inclination" of the pattern.

Certain age and secondary sexual characteristics enter, also, into the problems of "pitch."

The relation of the leg to the foot in the infant foot is different to that of the adult; in men different to women.

It has already been pointed out that the perpendicular relation of the leg and foot is strictly true of the adult foot only up to seven inches from the ground. The reason for this is that the front line of the leg is really concave, the hollowest part being the lowest. Above the seven-inch point the leg begins slightly to bend outwards again from the perpendicular position.

This outward bending is more immediate with the infant foot; least so with the male adult foot. As a consequence, infant work requires to be almost "bell-shaped" at the top of the leg. Men's work requires a quicker deflection backward of the leg line (in short work) from the perpendicular.

The methods of pattern design adopted must provide for these varying conditions, and it will remain for us in the succeeding chapters to endeavour to show how this may be done.

Chapter IX

WOMEN'S STANDARD PATTERNS.

What should be the guiding principles in the formation of a system of standard construction? Surely, the shape, proportions, and phenomena in action of the foot itself.

It is assumed these things are regarded in the structure and formation of the last to which a standard pattern is to be produced. The initial process in standard production being the construction of a cover pattern, it is agreed that these fundamentals are regarded in the lower part of the pattern, in so far as this pattern is itself an accurate fit to the last.

Now the majority of the systems of upper pattern constructions go so far with the definition stated. That is to say, they proceed upon the basis of a first production of a cover pattern.

The production of a standard direct from the last, without first taking a forme, is nearly obsolete.

There is, however, a vast variety in methods of upper pattern construction following upon the construction of the forme and embodying different methods of its use.

These methods are nearly all founded upon arbitrarily derived points, fixed in relation to the forme upon certain data expressed in measurements that have little or no relation to the proportion of well-defined points in the structure of the foot.

Thus, one system is founded upon the assumption that the "ankle height" is one-half the foot's length. If by "ankle height" is meant the ankle itself—and the definition would imply this to be so—then it has to be said that the ankle itself is situated at a point from the ground line quite other than at a point distanced at one-half the foot's length, measured from the ground; and more nearly at one-third than one-half.

The position given by this measurement is a point, no doubt, of value to the pattern-cutter; it has, however, but small relation to the ankle, and it is a misnomer to call that "ankle height" which is in reality a low middle leg measure.

The following system also illustrates the same point. Thus we are told:

"This method is based upon the longitudinal loca-

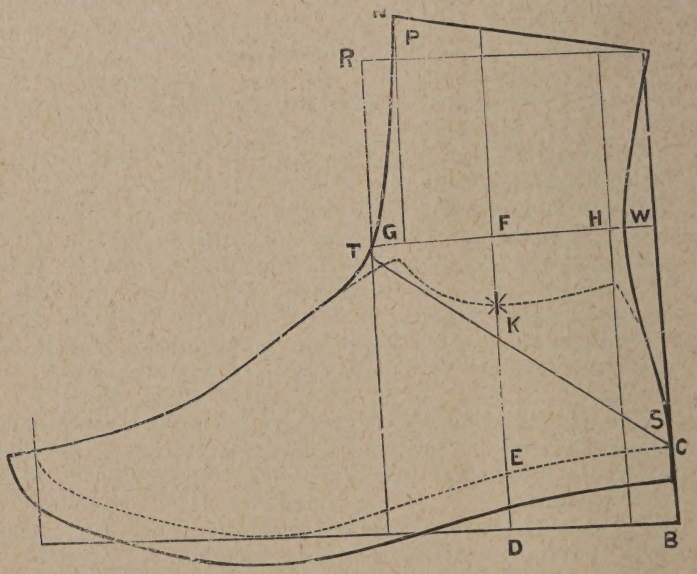


Fig. 117.

tion of the 'ankle' in relation to the foot's length, and this proportion also gives the 'ankle bone' height from the margin of the foot."

Let us see how these high principles are embodied. The instructions are:

"First obtain a forme, or surface area of the last. Place the forme upon a piece of paper to be used for the standard construction, and trace its outline (figure 117). From C measure, in a downward direction, the height desired, less forepart substance. Correct this point B with the swell of the joint, and construct the base line. At A and B erect perpendiculars of suitable length, so that they pass the toe-end and extreme

back of the forme, respectively. The base-line A B is divided into four equal parts, and one of the sub-divisions measured from B is marked D. Through this point erect a perpendicular. From E up the perpendicular line mark the distance, B D, and thus obtain *. Measure from * 1 2-9 inches, and indicate F. Through F. make a line parallel to A B, and on either side of F make one-quarter of the ankle measure, G. and H. Through G. and H. draw a line perpendicular to A B; decide the height of pattern and mark.

"Below * make K at a distance of one size, i.e., 3-9in. Passing K, draw the heel-line from C towards the 'throat.' If working from a heel measure taken direct from the foot, which is round, allow for the squareness of the last by measuring from C 2-9in., and fix S. From S the half-heel measure is to be placed towards T. From R mark P at a distance of 4-9in Above P locate N ½in. away. The leg measure is to be taken backwards from N. Complete the pattern as illustrated, noting when passing H that W is some 2-9in. away. This is necessary, because the last length was used instead of the foot, and patterns must not be scooped out here."

Now, a plain criticism of this and corresponding methods will clear the way for the further discussion of the matter opening this chapter.

First of all then, let it be noted, "this method is founded upon the lengthwise relation of the ankle to the foot's length," and that this, in the terms of the instructions, works out at one-fourth of the total of the length, plus one inch. Probably, this is a correct proportion. The system also claims to give the "ankle-bone height from the margin of the foot." Let us see how this is arrived at. Observe the diagram once more. From D up the perpendicular D F the distance B D (equal to one-fourth of the total of the length, plus one inch, or, otherwise stated, equal to one-fourth the length of the last), and to this amount an amount of 1 2-9in. is added, and thus the position of the "ankle bone" is said to be obtained.

Now, the reader will have found by the chapter on "The Form of the Foot" that this position on a range of feet* measured from the ground may have as much as half an inch difference.

*Of the same length.

Now, the system exemplified involves the measurements of this point from the ground, without so much as stating the size the identical figures refer to; and gives a fixed distance for the point, to be applied, apparently, for all sizes and all characters of feet. In view of what has already been stated as to the variability of this position, this is, obviously, inadequate.

There is a glimmer of perception of truth in the method in that it does, to a limited extent, restrict the variation of

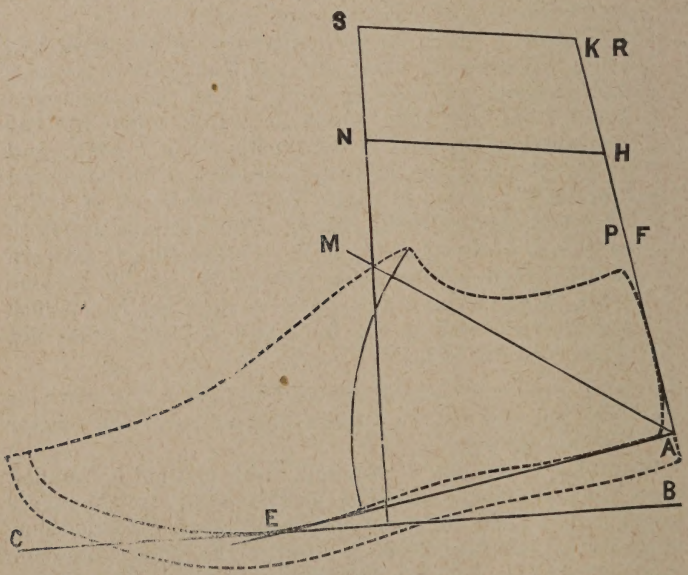


Fig. 118.

the position by utilising a measurement founded upon an alleged constant proportion existing between the distance of the desired point from the ground-line and the length of foot. What this proportion may be is not made at all clear by the exposition of the system.

The measurement B to D (equal to one-fourth of the length of the last) is the fundamental of the method. The fact that this measurement is derived from the length of the last, rather than from the foot, creates a suspicion as to its scientific value. When, further, the setting out of this measurement involves the inclusion of the lasting allowance (varying as this does with the method of manufacture,

whilst the method of manufacture is not included as a factor), it becomes still more evident that the method is not of great reliability. Finally, the ultimate determination of the "ankle-bone height" results from the addition of an amount of 1 2-9in. to the distance of D to B. Why, in the name of wonder, should 1 2-9in. be the amount? Why not 1 6-9 or 7-9? No reason is given or implied; and it can be only supposed that the inventor found his first measurement did not square with the fact immediately under his observation, and the exigencies of the case demanded that this amount should be added; and forthwith it is written down as a mathematical formula.

Other systems are founded upon the arbitrary fixation of certain points in the standard, such as is exemplified in the following description here reproduced verbatim et literatim.

Figure 118 is a diagram illustrating the application of the rule, stated as follows:—

> "When the heel is raised, the curve at the back crosses a fixed upright line at a lower distance from the bottom than when not raised. This rule that the lower the heel of the boot the higher up the curve crosses the perpendicular line, and the higher the heel the lower the point of contact, enables guide-lines and positions to be fixed that will assist in the formation of the standard."

The application of the aforesaid rule is stated as follows:

> "A forme is made from the last to be used and laid upon a sheet of paper, from which the standard is to be cut. It is traced out, keeping the seat portion somewhat elevated, to accommodate the height of the heel. After pencilling its shape, the substance of the forepart of the proposed boot is decided, and this deducted from the probable height of heel the boot will carry when made. The remnant will be marked below the seat of the traced-out forme on a position similar to the direction in which the height of the heel is to be measured. Through this point B draw a straight line, B E C, touching the curve at the joint. Another line is made to pass from A to E, and perpendicularly to this line (A E), just touching the back of the forme, the line A F H K is drawn. This latter line is used to determine the points through which the back curve shall pass. To obtain these points, F and H are measured from A at distances varying according to the size of standard and the height of heel."

Appended is a table for ascertaining the height of F and H:—

Size Adult.	F	H 1in. heel.	H 1¾in. heel.
1 ...	2 3-16 ...	4 13-16 ...	4 1-16
10 ...	3⅜ ...	5⅜ ...	4⅝

This method is decidedly less pretentious than the first, and the non-critical mind can easily discover much that is loose and admitting of widely different interpretation in the hands of different operators. It is noted here as embodying characteristics of nearly all these systems, viz., that it

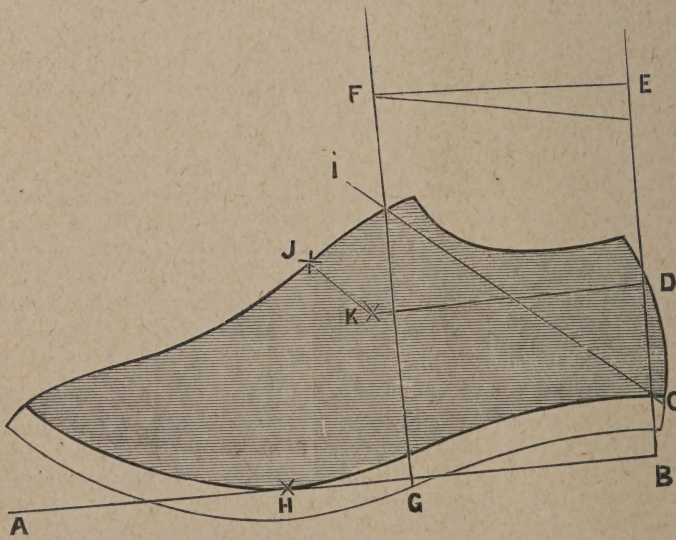


Fig. 119.

assumes a fixed relation to the ground of what is called the ankle-line as identical in all feet; and this system becomes so far dogmatic about it as to give a table of evenly-graded measurements that, with mathematical certainty, the point may be found.

Now, if it be true—and we have it on the word of so accurate an observer as Professor Virchow—that there is a wide range of variation in the position of this ankle point, then, plainly, only within a limited range can these systems be applicable and truthful. When, further, these methods are found to be quite disregardful of how much of the lasting allowance is included in the position ascertained by

these fixed measurements, we find still further ground for not respecting these modes, or, at any rate, as scientific systems of pattern construction.

It would not be necessary to labour this point, except for the reason that some who cannot accept these rather child-like reasonings have been deemed "old-fashioned." That it may be seen that we are not simply criticising one school only, let one further example be given of the embodiment of widely prevailing assumption.

Here the line A B represents the ground line; B C D E is a line at right angles to it. It is assumed that if the forme be placed in contact with the vertical line, with the seat point raised to C (the distance from B to C representing heel height), a point may be taken up the line that will yield a correct curve between the ankle point E and the counter-point D. The ankle line is taken as half the girth of the joint of the last; therefore, measuring that amount forward from E, the point F is found.

The instep point is determined by setting off a line, parallel with the grounnd line, equal to half the length of the last, from D,* equalling D K. From K set off a line 45deg., equal K J. Where it crosses the outline of the forme is the instep point. A curve is then made between the instep point J and the point F. The point E is arrived at by measuring up D C B from B, half the length of the last.

This method is wise in that it gives but few, and comparatively unimportant, determining positions, and depends for its success upon the trained skill of the pattern-cutter. One clearly-defined defect it has in common with many other systems. With a small heel measure and a large ankle measure, too much of the pattern would be in front of the line G F.

This method is usually worked in conjunction with a pattern marker, on which the counter heights and ankle heights are indicated. Here the fixing of these points does not matter much, simply because what is called the ankle line is really not the ankle position at all. The method is really a freehand construction.

Seeing, then, that in different types there is a varying relation between the ankle and the ground, it is impotent and vain to compile tables of heights and distances, pre-

* It should be noted that our author measures his last length from the back to the top of the puff; that certainly makes the use of the half last length as a determinant less obnoxious.

supposing a fixity and constancy of these positions in relation to the ground in all types, for such constancy plainly does not exist.

How, then, it may well be asked, is it that, notwithstanding these constant breaches of the fundamental law of a true procedure in pattern construction, so many patterns produced under plainly defective systems yet, after all, do, without struggling with 288ths of an inch, manage to fit the feet?

Is there, then, nothing in the process that matters?

Thus do we awake anew the battle of the philosophers around the common-sense school. One can almost hear the din and clash of the a priori and the a posteriori in the words of the question. But, just as empirical laws express accidental relationships found to subsist among phenomena which do not adequately explain the production of the phenomena, they may yet have value in that they form stages in the arduous journey of discovery for causal law. Yea! may even, after all, be found identical with that law.

Here, too, in pattern-cutting, empiricism frequently enough hits the mark, and bearing this fact in mind, and the burden of all that has been written concerning the form of the foot, the reader may be prepared for the answer; there is indeed but little in the detail that matters so long as the correctitude of the final form and shape be regarded.

In so far as patterns produced under erroneous systems are successful, they are so despite of the method, and because of an enlightened knowledge and true conception of the ultimate shape to be attained by and through them. Empirically derived as these facts and conceptions may be, and as so much of practical knowledge ever is, the occasional success by no means disestablishes the need for a process conceived upon correct lines; and such a process it will be our effort to advance.

Pattern-cutting is, so far, a branch of artistic labour that there is a prime necessity for a trained knowledge of "form." All that serves the growth of a true conception of the shape that shall result in a perfect-fitting boot must be sedulously sought and followed. All that will assist in the embodiment, and facilitate the production, of such a correct shape must be thoroughly learned. This is to impress the service of both science and art; and rightly, for have we not been told that the pattern-cutter is a "scientific artist"?

Now, it has been seen that in most of the systems of

pattern-cutting practised in the United Kingdom, the ankle position is considered to be correctly determined by taking "one half the length of the foot" or "one half the last length," and fixing the ankle line at such a distance from the ground line. It has been shown, also, that, owing to the great variability of this position, such a method of determination is, obviously, inadequate; that if such method were correct, then the average point indicated by it is, in truth, not an ankle position at all.

Now, there is a method of pattern construction introduced by Meilli, and further explained by Herr Franke in "Der Schubindufstrielle,"* worthy of close attention; and it would seem that along the line of the method there shown a solution of the problem before us may be discoverable. This method will be explained in full, and afterwards dealt with critically.

Like the majority of Continental methods, the pattern is produced entire, apart from the last, and the order of procedure is exemplified in the following diagrams.

The constructional lines in Herr Franke's method are as illustrated in the succeeding figures.

The first step is shown in figure 120, where c represents the height of heel and b the joint position.

The second step in figure 121.

The final stages in figures 122a, 122b, 122c, and 122d.

Figure 122c shows the method of ascertainment of ankle line position by bisection of the heel line,

and in figure 122d the method of setting back the front leg line.

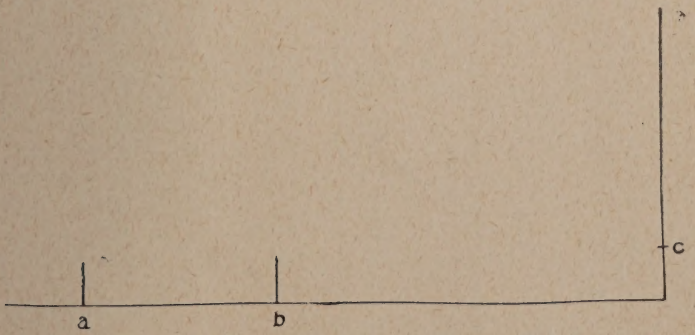


Fig. 120.

* "Der Schubindufstrielle," by R. Franke, Artem (Derlag des Derfaffers Artem in Thur., 1892).

Fig. 121.

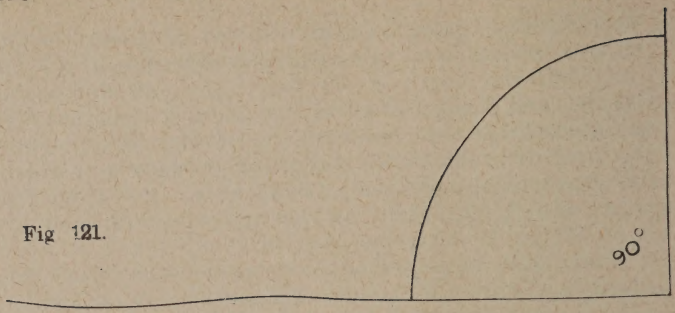


Fig. 122a

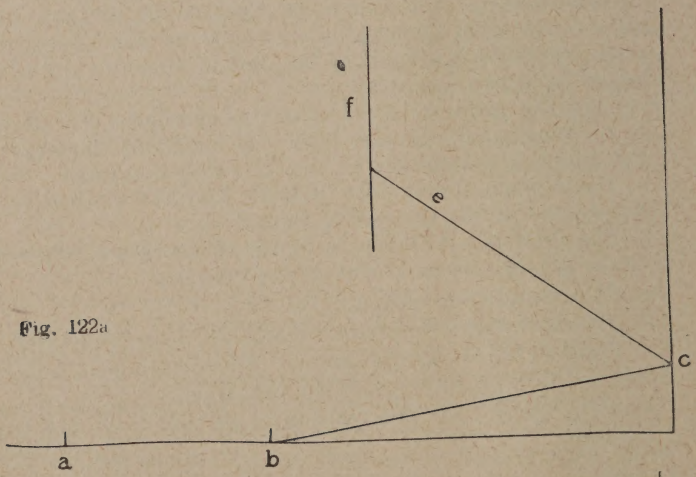
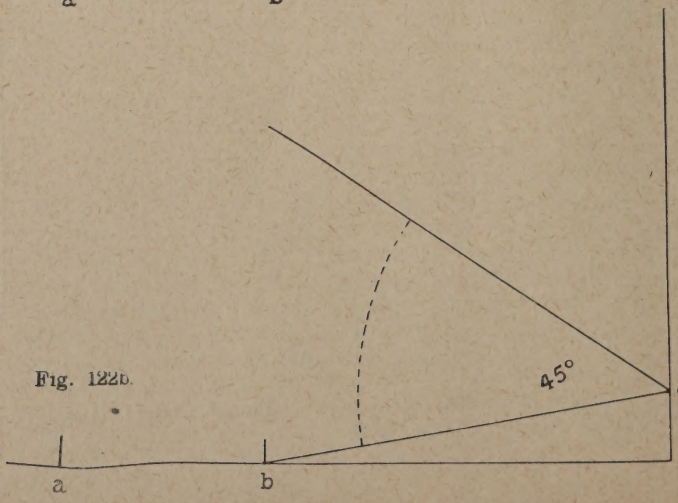


Fig. 122b.



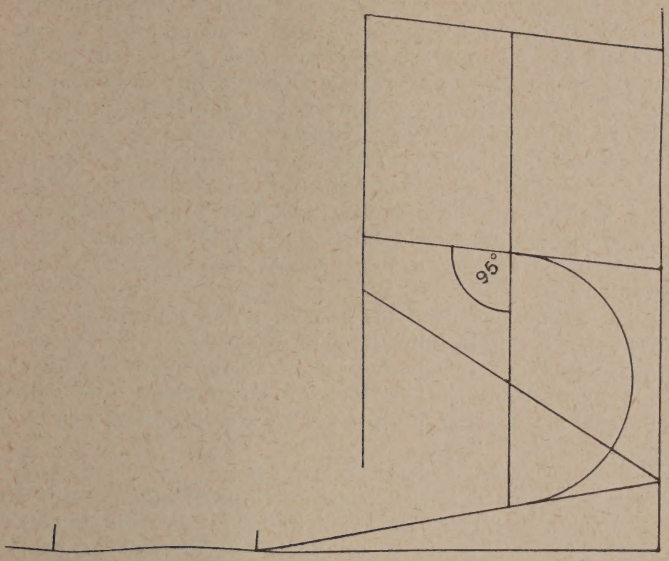


Fig. 122c.

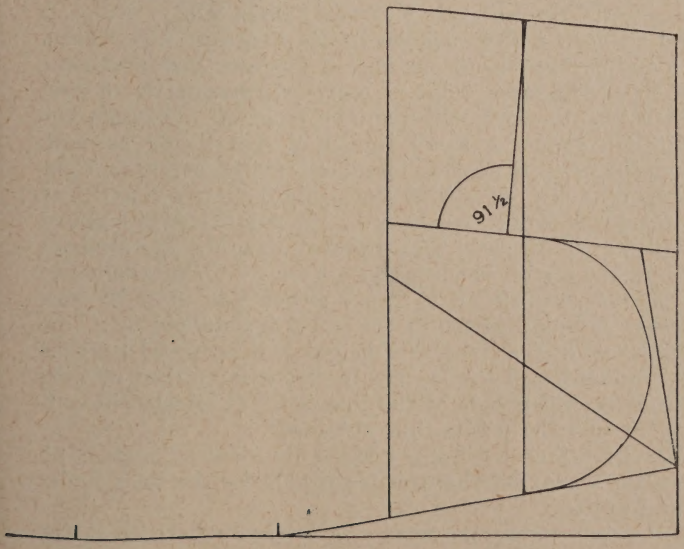


Fig. 122d

The ankle point in this method is located from a determination of the half-length of a side measure taken along a line drawn at an angle agreed to represent the true position of the heel measure. In any case, a line drawn at a position to approximate to this when bisected, the point of bisection will represent with accuracy the middle position in a perpendicular line of the ankle from the ground. So that, this being so, the angle of the heel measure being found, and the girth along that line determined, the point of bisection will enable the portion of ankle to be scientifically fixed. Examples of this method are given in figures 123 and 124.

This method has been practised for many years at the Regent-street Polytechnic Shoe Trade Classes, and the examples following of the application of the method under varying conditions are by Mr. Walter Bedford, and will help to explain the applicability of the method, and to demonstrate its truth.

The mode employed is as follows:—

Describe a line A B the length of the standard required. At B erect a line B C of convenient height at right angles to A B. From B mark off at D the height of the heel intended to be used, less sole substance. Upon A E D describe the net form with the joint touching A B at E. Join E D We will call E D the "pitch line." From D erect a line D F at 45 degrees to the pitch-line E D. From D along D F mark off one-half of the heel measurement; also from the same point D mark off one-quarter of heel measurement, which will give the point G. Through the point G produce a small line X X, parallelled to A B From the point G erect a line of convenient height at right angles to X X. Also from the point G erect a line G 1 at 94 degrees to X X. Again, from the point G, with a radius of quarter of the heel measurement, describe the segment J K, at the top of which produce a line Y Y, parallelled to X X; measure off on Y Y, on either side of G H, one-quarter of ankle measurement. Z Z is obtained by a line parallel to X X at whatever height it is proposed to make the standard, and the leg measurement is marked off one-quarter on either side of the line G 1. Complete the outline through the points thus obtained.

The pitch-lines need not necessarily be at an angle of 45 degrees; it may be whatever is suitable for the work under consideration.

Likewise, there is no need of arbitrary adherence to the same angle which has been used in this demonstration for

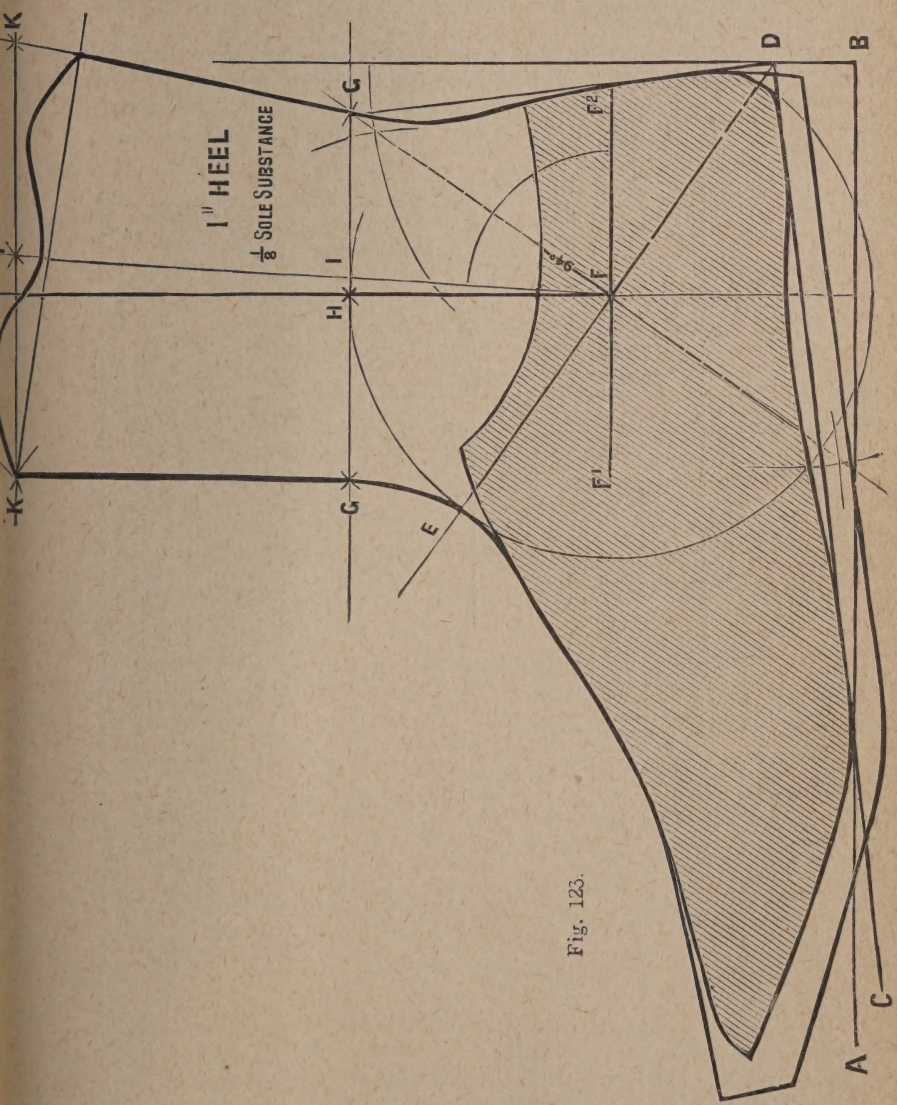


Fig. 123.

the leg determination line G 1. But X X must be parallel to the base line and likewise the ankle determination line A G must be at right angles to X X.

In the construction of an infant's standard up to size 9's, the line G H would be used for the determination of both ankle and leg measurements, as the muscles of an infant's

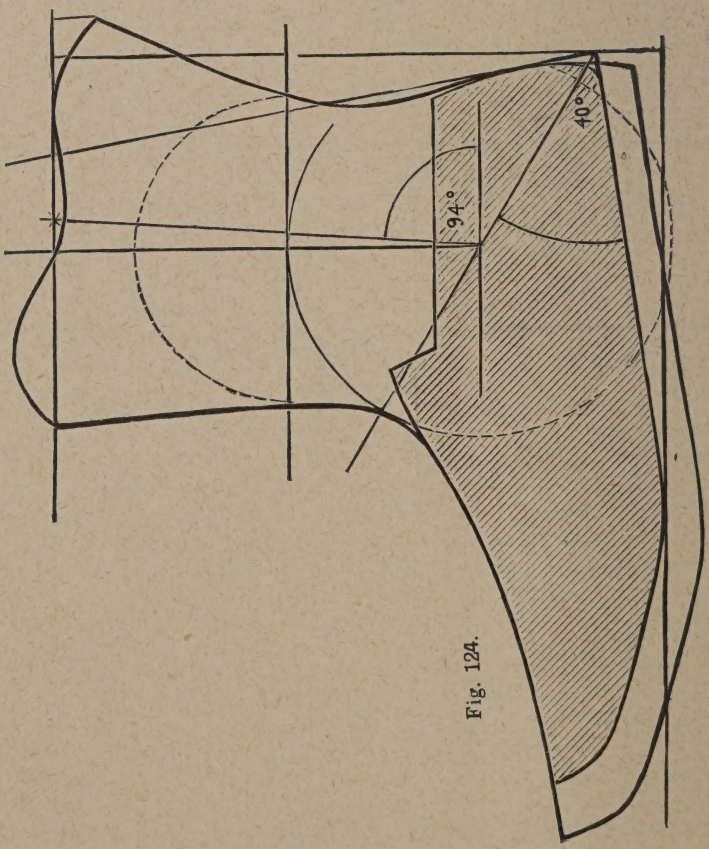


Fig. 124.

leg are situated relatively much lower, and the leg itself is shorter in proportion than an adult's; also the tarsal region is very undeveloped, thus giving an extremely small heel measurement, while these circumstances together give the leg a bilaterally symmetrical appearance.

Example I. (figure 126).—Lady's standard size 5.

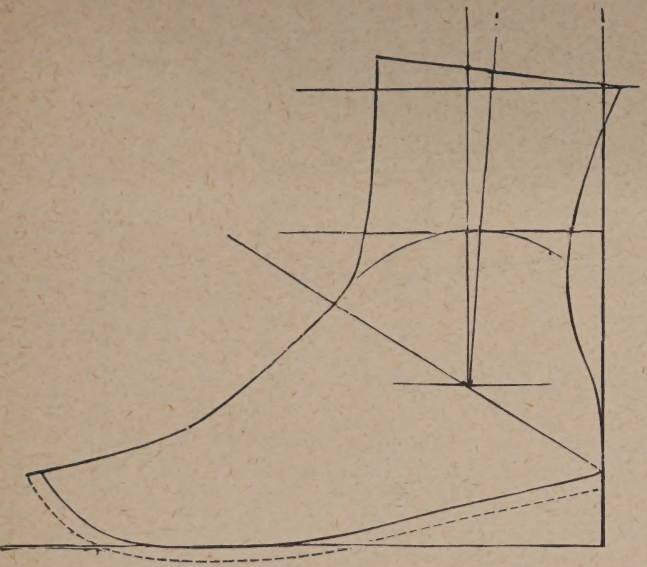


Fig. 126.

Heel.	Ankle.	Leg at 6in.	Heel.
12in.	8in.	9in.	1¼in.

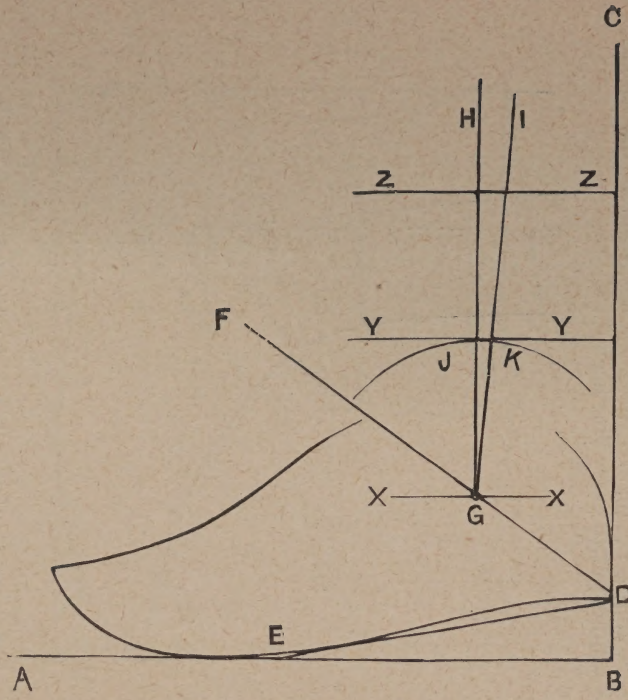


Fig. 125.

Example II. (figure 127).—Same measurements as first example, but to carry $\frac{3}{4}$in. heel.

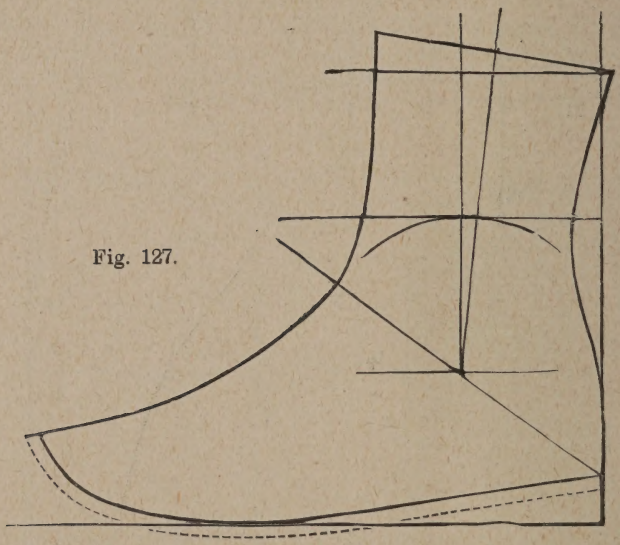


Fig. 127.

Example III. (figure 128).—Lady's standard size 5.

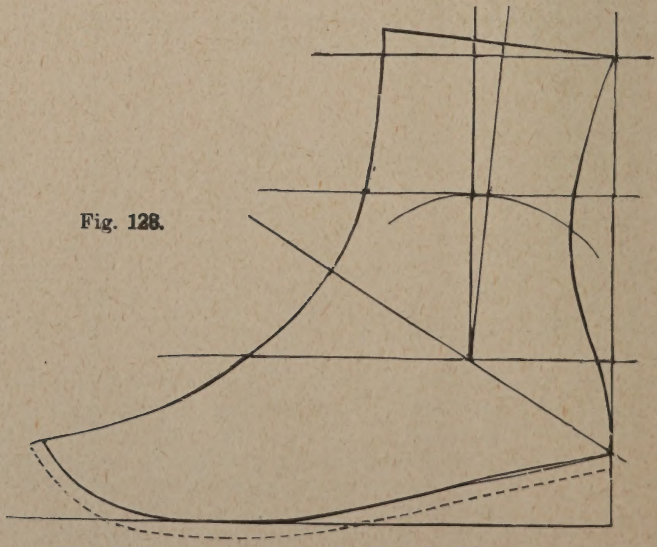


Fig. 128.

Large Heel, Small Ankle and Leg.

Heel.	Ankle.	Leg at 8in.	Heel.
12½in.	7½in.	8½in.	1¼in.

Example IV. (figure 129).—Lady's standard size 5.

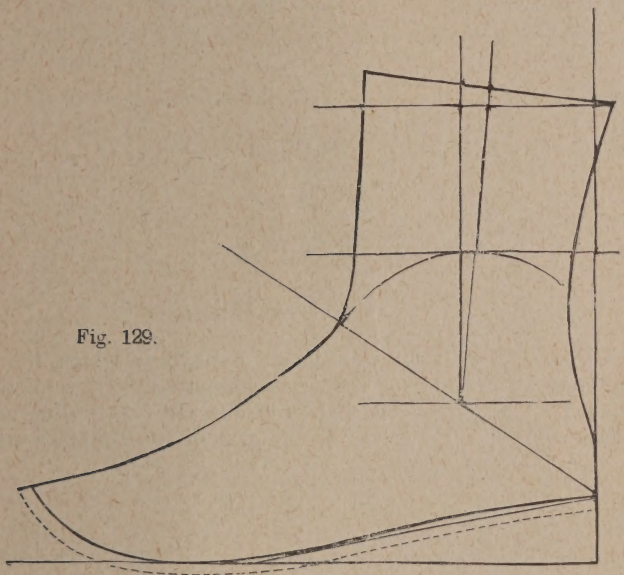


Fig. 129.

Small Heel, Large Ankle and Leg.

Heel.	Ankle.	Leg at 8in.	Heel.
11⅞in.	8½in.	8½in.	1¼in.

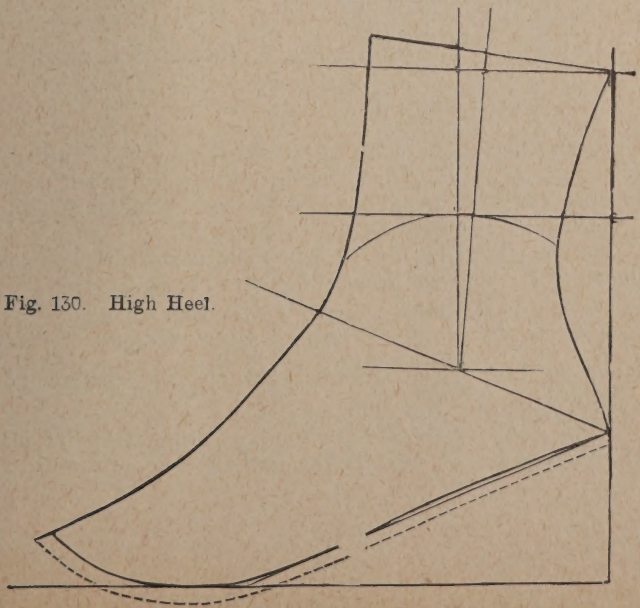


Fig. 130. High Heel.

Chapter X.

PATTERN-CUTTING.

In the earlier chapters, reasons have been given for a difference in method for men's as compared with women's patterns. The same order of procedure in the production of the forme is followed as in the case of the women's and

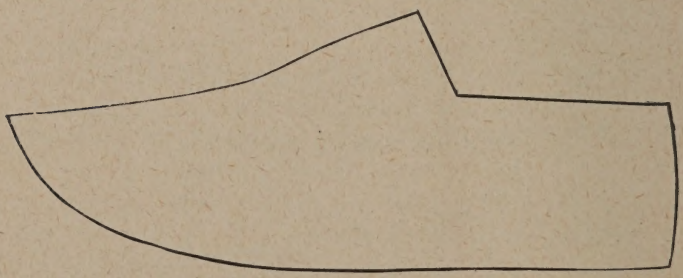


Fig. 131.

children's patterns. That is to say, it may be obtained by trial from the last, or by a method of mitred or slit paper; in both cases the result being corrected by measurement.

Such a net forme is shown in figure 131.

The length of the last to which the pattern is being produced is 7. The girth measurements are as follow:—

Joint.	Instep.	Heel.	Ankle.	Heel Angle.
8½	9	12¾	8½	40deg.

Height of heel of boot is to be 1⅛in., the sole substance ¼in.

The procedure is as follows:—

First, describe the rectangle a b c; from b up b c mark the amount of the heel height, less the sole substance, i.e.,

$1\frac{1}{8}$in.—$\frac{1}{4}$in.=$1\frac{1}{4}$, giving the point d. From d along a b mark a point e representing the distance of the outside joint of the last from the back of the heel, and marking the prominence of the "swell" of the joint. Mark d f at right angles to d e.

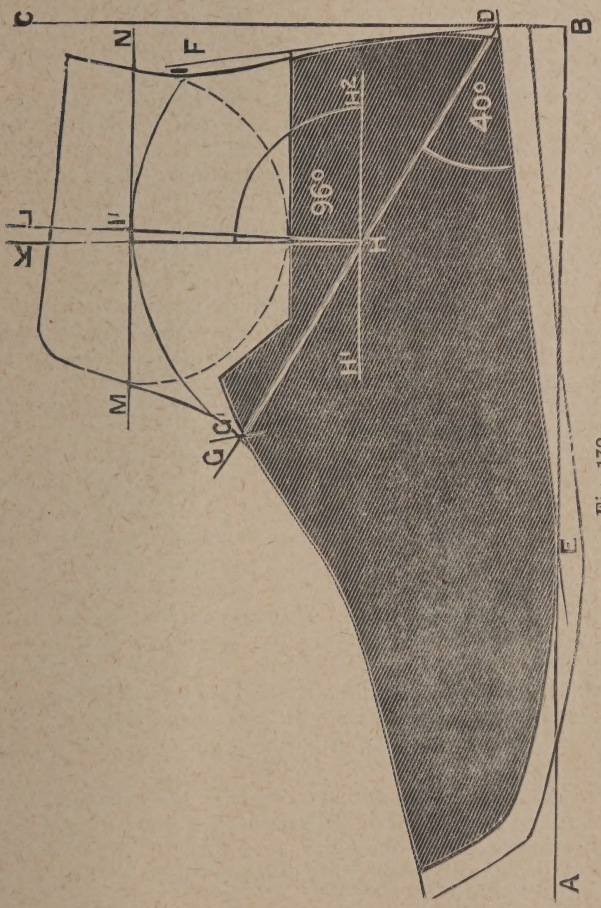


Fig. 132.

Second, upon d e, keeping the back of the forme close to d f, describe the outline of the net forme.

Third, from d set off the heel line ascertained by measurement of the foot to be at 40deg., the line d e giving the line d g. Along d g set off one-half the heel measure.

Bisect d g1 and thus obtain the ankle centre H; from H, perpendicular to the line h1 h2, erect the perpendicular H K.

Fourth, with H as centre, and H g1 as diameter, describe the arc g1 i. At an angle of 96deg. set off the line H L. Set off the ankle-line parallel to the ground line a b, tangent to the arc g1 i. On either side of point L1 set off one-fourth of the ankle measurement.

From the points thus obtained complete the figure, adding afterwards the amount required for lasting allowance in accord with the class of material of which the boot is to be made, and also the method under which it is to be made.

Pattern production, both for men's and women's work, may thus be conducted upon regular methods, such as have been indicated.

In actual practice a large amount of pattern cutting is, of course, done by the direct production of patterns from the last. This can be done only by men of great experience and well-formed ideals. It may be true or false to "cut to the eye." It depends entirely upon the education, experience, and ideals at the back of it.

A last with a small bottom width and normal measurements will throw the pattern nearest in general outline to that of the finished boot. The greater the sweep, the bolder the outline of the last, and the greater bottom width, the more backward in appearance will be the pattern as distinguished from the appearance of the finished boot. It is of the utmost importance that sufficient stuff should be left in the pattern at the waist; that it should have only in very exceptional cases any concave curvature.

When the lasts are of an extremely twisted form, it is necessary to cut the pattern in rights and lefts, by cutting two distinct patterns to separate formes, one for each side of the last.

In the division of the parts, and for differing methods of bottom attaching, varied allowances for seams, lasting over, and underlays are necessary, and have to be allowed for on the standard upon whichever method it may be produced.

These allowances, stated generally, are as follow:—

Lasting Allowances.

	Forepart	Seat
Hand-welted (glace, light box, etc.), men's ...	$\frac{7}{16}$ ..	$\frac{5}{8}$
Do. do. women's	$\frac{3}{8}$ ...	$\frac{1}{2}$
Machine-welted, men's	$\frac{1}{2}$ ...	$\frac{1}{2}$
Do. women's ...	$\frac{7}{16}$ ...	$\frac{5}{8}$
McKay-sewed, men's	$\frac{1}{4}$ ...	$\frac{1}{4}$
Do. women's	$\frac{1}{4}$ ...	$\frac{1}{4}$
Pump work generally	$\frac{1}{4}$ ...	$\frac{1}{4}$

Seams.

Glace kid, light box calf, etc.	$\frac{1}{16}$
Stouter leathers	$\frac{1}{12}$
Lastings and similar fabrics	$\frac{3}{16}$ to $\frac{5}{16}$

Underlaid Seams.

Glace kid, light box calf, etc.	$\frac{1}{4}$ to $\frac{5}{16}$
Wax calf, etc.	$\frac{5}{16}$

The standard construction admits of division into different component parts, and these differently united, constitute the varying styles and varieties of boots and shoes. These varieties and their construction will be treated of in a separate chapter.

Chapter XI.

GRADING.

The fundamental principle applied to practical grading is that involved in the statement of the qualities of "similar triangles," and of the problems concerned with the measurement of plane triangles. It is easy to show from the sixth book of Euclid that, if we fix the values of the

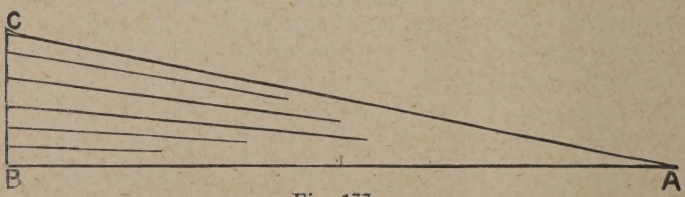


Fig. 133.

angles of a triangle, the ratio of the sides containing any one of these angles is the same, whatever the size of the triangle. The triangle is the fundamental figure of plane geometry, and in modern times a whole system of geometry has developed itself, and is known as the geometry of the triangle, in which an endless number of remarkable properties are discussed.

These properties of the triangle are utilised in the grading tool used by shoe designers.

The largest amount of difference separating the lines in the figure is along the line B C. Assuming these differences to be one-third of an inch, division made at half the length, and perpendicular to A B, would give a separating width of one-sixth. Likewise, at one-third of the length, a separation of one-ninth. The difference between the spaces

across the tool is in proportion to the distance from A and to the difference indicated on B C.

It is this application of the qualities of the triangle which is utilised in the boot-grading tools, both hand and machine.

The principles of mechanical grading are exemplified in the copying apparatus (for this purpose now superseded by photography) known as the "Pantagraph." It was invented so long ago as 1631 by the Jesuit, Christoph Steiner, and improved 200 years later by Professor Wallace, of Edinburgh.

The instrument is made in various forms, all embodying

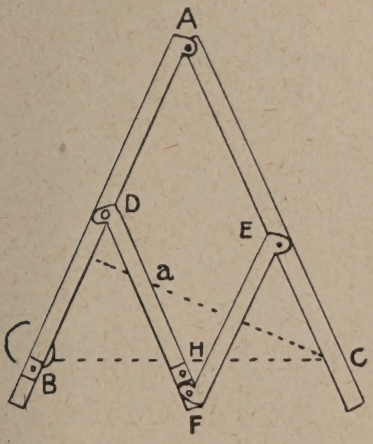


Fig. 134.

the same mathematical principle, and one of the forms is shown in the accompanying drawing.

Four rods are so hinged to one another that A E is equal to D F, and A D to E F; hence, A D E F is always a parallelogram. If from a given point, C, on A E, any straight line, B H (or a b) be drawn, intersecting the other arms, the triangle A B C will always, no matter how the arms of the instrument be moved, be equal to the triangle D B H.

It follows that if the instrument be pivoted on a point at B (usually by a weight) a pencil-point inserted at H, and a tracing-point at C, the latter traced over the lines of a drawing, the pencil point at H will trace a reduced copy of the drawing. The proportion of the reduction will be as

B H is to B C. B and H are made to slide on their respective rods, so that varying proportions of reduction may be made.

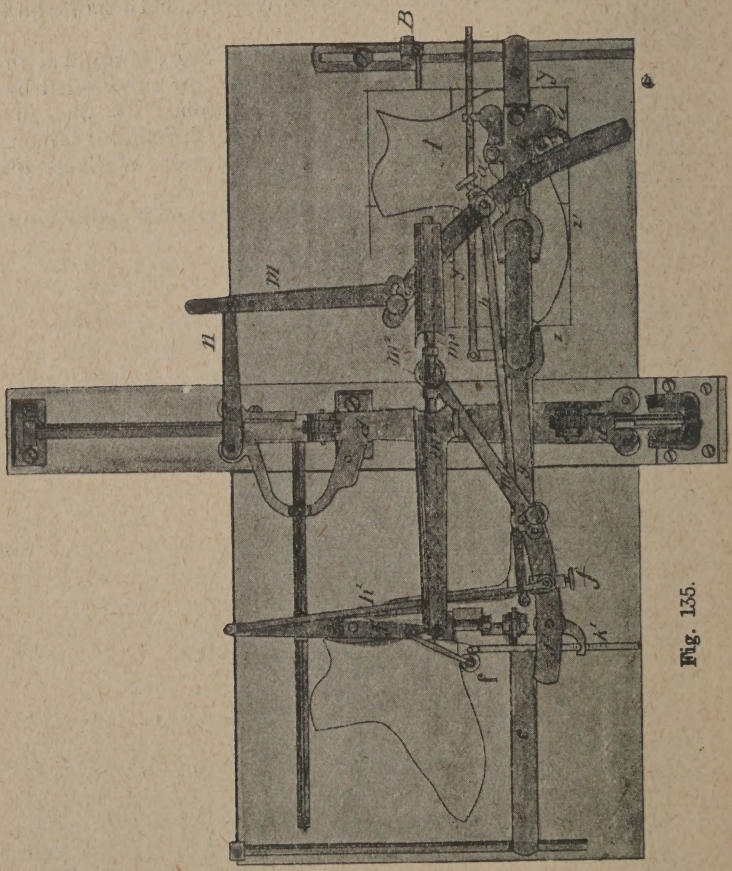


Fig. 135.

The essential mathematical principles of the pantagraph are embodied in an elaborate form in the Hartford grading machine, the structure and method of which is explained in detail by the following diagrams.

Figure 135 is a plan of the machine embodying all the

features of this invention. Figure 136 is a modification of one of the devices; whilst the remaining figures show quite clearly the details of construction of the apparatus.

The modern form of the machine requires a bench space of about five feet by three, whilst the bench itself should be about three feet from the ground, and perfectly level, and screwed firmly to the bench.

In the figure it will be seen that the tracer a is mounted upon a carriage, b, which is so mounted upon a support, c, that the tracer has a universal motion in one plane. The marker, f, is in like manner mounted so that it also can move freely in any direction in one plane. Its carriage is

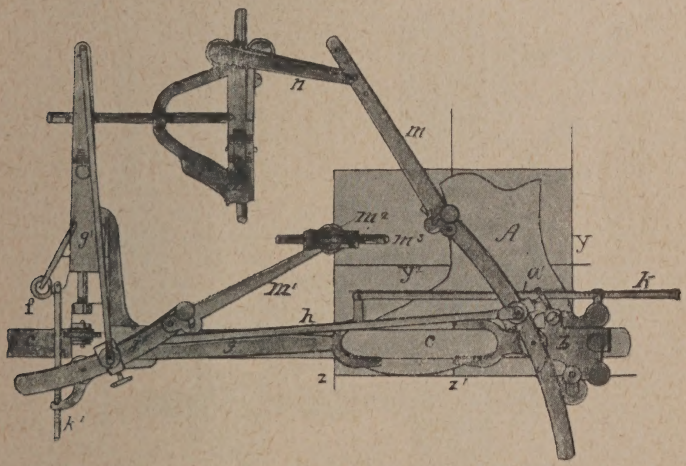


Fig. 136.

marked g, and it is supported upon the support c, so that it can be moved from side to side quite freely.

In the drawings both the tracer and marker are shown upon carriages, b and g, and both these carriages sliding upon the support c, which is fast to the support d.

In order that the tracer and marker may have the universal motion above explained, and yet allow them to be connected together, they will now be explained.

The tracer carriage b is connected to the marker carriage g by means of a radius bar, h, which is centred upon the marker carriage g, and adjustably connected to a cross bar, j, which is centred upon the tracer carriage b. When this radius bar h has its right-hand axis coincident with the

axis which connects the cross bar j and the tracer carriage b, any motion of the tracer to the right or left will cause the marker to move precisely the same distance and in the same direction, and in like manner any motion of the tracer up or down will cause the marker to move precisely the same distance and in the same direction (if the motion of the marker be not effected by the radius bar h^1 and the cross bar j^1, the influence of which for the moment is disregarded).

By this portion of the apparatus (that is, minus the radius bar h^1, and the cross bar j^1), a figure will be marked out by the marker precisely the same as the figure described

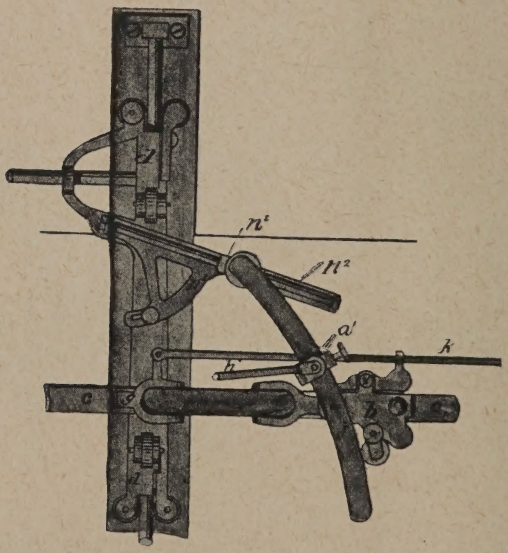


Fig. 137.

by the axis of the tracer, if the axis of the radius bar h coincide with the axis of the cross bar j. Or, in other words, the two carriages b and g will always be in precisely the same relation one to the other.

The cross bar j changes its position relatively to the tracer carriage b with every movement of that carriage, because at one end its movement is restricted by the connecting rod m, and it is thereby compelled to turn upon the axis by which it is connected to the carriage b.

Hence (as will be clear to the reader), the size of the

figure described by the machine in lines parallel with the support c may be made less or more than the size of the figure described by the tracer along corresponding lines by shifting the slide a^1 to one side or the other of the axis by which the crossbar j is connected to carriage b, and the decrease or increase along these lines will depend upon the distance between the former axis and the axis by which the radius bar h is connected to the slide a^1.

It is this combination of a tracer and marker by means of a radius bar and cross bar which constitutes the main feature of this invention.

The apparatus, as so far described, is specially adapted

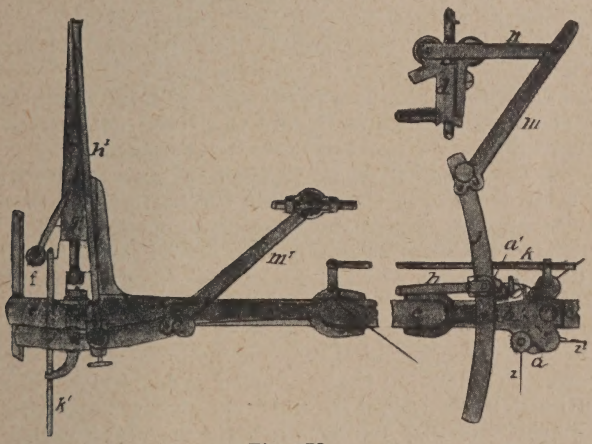


Fig. 138.

for the grading of patterns for soles, but as these patterns vary in size, not only lengthwise—that is, in lines parallel with the support c—but also widthwise, in sole patterns, or from top to bottom in upper patterns—that is, in lines parallel with the support d—a second apparatus substantially the same as the one described, but at right angles to it, becomes necessary for grading these patterns.

In this second apparatus the radius bar is marked h^1, and the cross bar j^1, the index rod k^1, and the connecting rod m^1.

A secondary carriage g^1 is mounted upon the carriage g, so that it is free to move toward and from the carriage g, and the two are connected together not only by the ways upon which the carriage g^1 slides, but also by the radius bar

h^1 and the cross bar j^1, as shown in the diagrams. The secondary carriage g^1 carries the marker f.

The operation of the two carriages g and g^1, radius bar h^1, cross bar j^1, and slide f^1 is the same as before explained in regard to the carriages b and g, radius bar h, cross bar j, and slide a^1, except, of course, that when the axis which connects the radius bar h^1 and slide f^1 coincides with the axis which connects the cross bar j^1 and carriage g, the figure described by the marker is identical with that described by the tracer (except as changed by the apparatus a^1, b, h, and j); and to vary these figures in lines parallel with the support d, the axis of the radius bar must be shifted to one side or the other of the axis of the cross bar, these lines growing shorter in the figure marked out than in that described by the tracer in proportion as the former axis is carried toward the connecting rod m^1.

The connecting rods m and m^1 may be made in one piece with the cross bars j and j^1, and they need not necessarily be segmental.

If the cross bar j be centred when the axis of the tracer is in a line midway of the length of the pattern and parallel with the support d, and the tracer h then moved to a line parallel with the midway line and the distance equal to one-half the length of the pattern from it (see figure 135), the carriage b and g will be separated more or less as the slide axis of the radius bar h is more or less removed from the axis of the cross bar j, and the amount of this separation will be shown on the graduated index rod k. Consequently, if it be desired to make the pattern described by the marker one size smaller than the standard pattern A (around which the tracer is to travel), the slide a^1 is moved upon the cross bar j just far enough from the axis of the cross bar to move the marker f one-sixth of an inch farther from the tracer than it was when the tracer axis was on the midway line.

In other words, when centred, the tracer and marker are each upon the midway line; the tracer upon the midway line of the standard, and the marker upon the midway line of the figure, which it will describe; and when the tracer is brought to the extreme point in its motion away from this line, the marker will be brought in the same relation to the midway line; and, consequently, if the marker at this extreme be one-sixth of an inch nearer to its midway line than the tracer to its midway line, it is clear that the extreme points passed over by the marker, one each side of its midway line, will be each one-sixth of an inch nearer its

midway line than the extreme points passed over by the tracer and its midway line.

The figure described by the marker will, therefore, be one-third of an inch shorter than that described by the tracer, the usual allowance between size and size in length.

To illustrate from the drawings: When the cross bar j is centred while the tracer axis is upon the midway line of the standard, the point of the marker is brought, of course, upon the midway line of the figure which will be described by the marker, and when the tracer axis is brought upon the extreme line y of the standard the marker point is brought upon the corresponding line of the figure it describes. Now set the marker point one-sixth of an inch nearer its midway line than the tracer is to its midway line by moving slide a1 to the cross bar j, and then clamp slide a1 to the cross bar j. After this is done, when the tracer axis is carried around the standard A, the marker will also

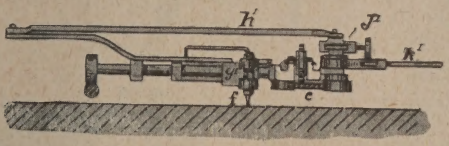


Fig. 139.

be caused to describe a similar figure, but shorter by one-sixth of an inch on each side of the central line, or one-third of an inch in all along its greatest length, and diminishes in length along any line parallel with the support c, the amount of diminution having the same proportion to one-third of an inch that the length of the given line bears to the length of the longest line in the standard parallel to the support c.

If it were always desirable to centre the cross bars on the midway lines, the connecting rods m and m1 might be made in one piece with the cross bars. But inasmuch as it is important to provide means for centreing the cross bars not only on the midway line, but also on the extreme lines y or z, the connecting rods m and m1 are made separate from the cross bars j and j1, and connected to them by clamps. This is an important feature of the invention, and enlarges the scope of the apparatus. For example: Centre the cross bar j when the tracer axis is on the extreme line z, and clamp the slide a1 at some distance from the axis of the cross bar; then move the tracer axis to the

other extreme line y, and the index rod k will show how much the tracer and marker have been separated by this movement (supposing the slide a^1 to be between the axis of the cross bar j and its connecting rod, the two carriages being drawn nearer together, if the slide be the other side of this axis), then unclamp the slide a^1, and move it upon the cross bar until the marker point is brought the desired distance from the point where it was when the cross bar was centred the greatest length of the desired figure, taking care, of course (by means of a proper stop, B, or otherwise).

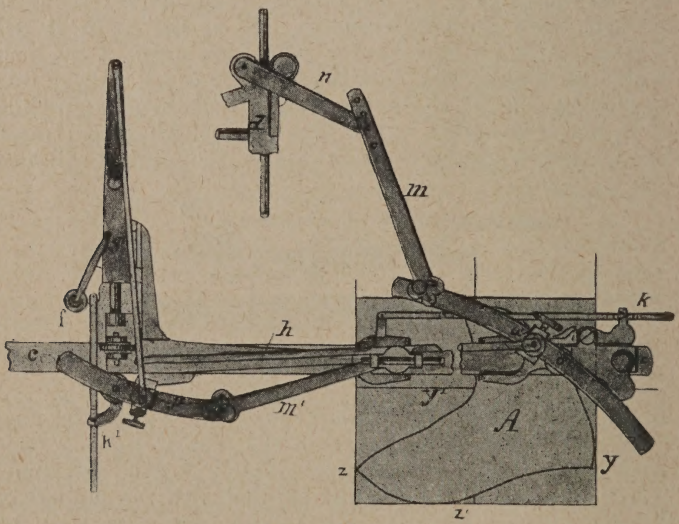


Fig. 140.

to keep the tracer axis upon the extreme line y while adjusting the slide a^1. When the slide a^1 is properly adjusted, reclamp it upon its cross bar. The result, as is clear, will be that the extreme lines on the figure described by the marker will be nearer together than the corresponding extreme lines y and z of the standard, the marker point always coming upon the line corresponding to z when the tracer axis is on z, and travelling away from that line a less distance than the tracer travels from the line z of the standard. When centred upon the extreme line, the distance indicated upon the index rod is, of course, the whole difference between the longest line of the standard and the corresponding line in the figure described by the marker,

instead of half that distance, as when centred upon the midway line.

Figures 139 and 140 are diagrams, the first representing the tracer axis upon the intersection of the two extreme lines z and z^1 (z indicating a line through the extreme left-hand point of the standard A, and z^1 a line through the extreme lower point of standard A), and showing both cross bars j and j^1 centred; and the second representing the tracer axis upon the intersection of two other lines, y and y^1 (y indicating a line through the extreme right-hand point of the standard A, and y^1 a line parallel with z^1, and at a distance from it equal to one-half the extreme length of standard A, or one-half of the distance from z to y). When in this latter position the slides a^1 and f^1 may both be adjusted to cause the figure described by the marker to vary as desired from the standard.

The methods of adjusting the cross bar j^1 and slide f^1 require no description, in view of what has been said about adjusting the cross bar j and slide a^1, and, as will be clear, the slide f^1 may be adjusted upon the cross bar j^1 when the tracer axis is at any point in the line y^1 (or any other proper adjusting line), just as the slide a^1 may be adjusted upon the cross bar j when the tracer axis is at any point in the line y (or any proper adjusting line), although it is only when the tracer axis is at the intersection of both adjusting lines that both the slides can be adjusted.

The usual adjustment of the slide f^1 in making shoe patterns is from the line Z^1 to the line y^1, or one-half the length of the standard.

The index rod k^1 is set accordingly.

The cross bar j^1 is controlled by the connecting rod m^1, one end of which is secured to the slide m^2, which travels on the rod m^3, this rod being secured to the bracket m^4.

In upper patterns the height and width of the ankle part are greater in proportion in the small sizes, and a set of properly graded patterns should have the ankle part decreased slightly less than any other portion as the patterns decrease in size, the largest size having the ankle part lower and narrower, in proportion to the rest of the pattern, than the smallest size.

This may be accomplished in this machine to a greater or less extent, to suit the taste of the pattern maker, by adjusting the connecting rod m, or by changing the slant of the rod n^2.

The fact that that motion of the marker which is caused by the motion of the cross bar j and j^1 is greater or less (on

the well-known principle of the crank) in proportion to the relative positions of these cross bars and their respective radius bars also causes this variation in the proportion of the ankle part to the rest of the pattern.

The tracer (shown in detail in figures 141, 141a, 141b, and 141c) also constitutes an important feature of this invention. Its distinguishing feature is that the bearing surface a^2 is free to move around the axis a^3. This bearing surface may be a disc journalled on the piece a^4, as in figures 141a

Fig. 141.

Fig. 141a.

and 141b, or may be rigidly attached to the piece a^4, as in figure 141.

Figure 142 is the right-hand radius of the latest pattern of the "Hartford" machine. In order to grade sole patterns, first see that the right-hand radius is adjusted as

Fig. 141b.

Fig. 141c.

shown in figure 142. That is to say, the radius arm must be in notch 2, and the thumb-pin on the extension slide must also be in hole marked 2. After fixing these, tighten wing nut marked 4. Now fix the initial pattern, placing the pattern with the widest part of the joints on horizontal line on table of machine marked 0; bring the follower on opposite side of the joint at the widest part, and adjust the width stop with thumb-screw into notch on follower carrier as shown in figure 146. The machine is thus adjusted for the width. Now place the toe of the initial pattern level with the vertical line on left-hand side of the table marked 2, and bring the follower close to the heel; then adjust the length stop as shown in figure 146. The machine is thus set for length and width.

The initial pattern has now to be bolted down to the table of the machine, as shown in figure 146.

The 1-3in. scale is, of course, always used for lengths; but for widths, 1-11in., 1-12in., 1-13in., or 1-15in. may be used.

The knife fitted in the socket of the knife carrier and the glass-cutting bed placed in position, and the paper fixed firmly, the operator is now in a position to grade and cut the set.

To grade upper patterns:—

First throw the bar of the right-hand radius, shown in

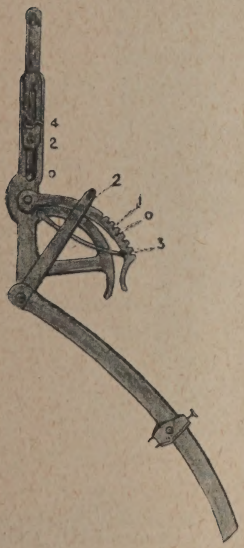


Fig. 142.

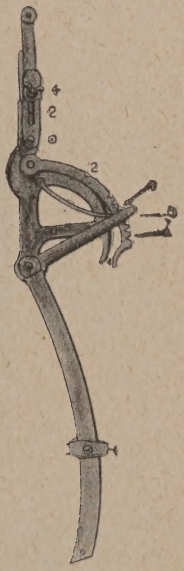


Fig. 145.

figure 143, into the notch marked 0. Tighten wing nut 4. The arm must now be slid towards the operator, and the thumb-pin inserted in the hole marked 0. Tighten wing nut 4. Now change the scale, the length from 1-3in., used for soles, to 1-6in., on the opposite side of the brass rod. The width scale from 1-12in. to 1-8in. Fix the marking wheel or scratching point in place of the knife.

Now take a strip of paper about one-inch wide, and measure the total length of model pattern it is intended to grade from, as shown in figure 144. Snip the paper off to

equal the exact length; fold this in half, and this will give the half-length of the pattern necessary for settling the length stop. Now measure the pattern across the instep in the same manner, adding three-eighths of an inch.

Thus we have obtained half-length and half-width on the strips of paper. These are placed upon the machine in the manner shown in figure 144, the length line against the vertical line marked 0 running down the centre of the table. This being done, bring the follower on the other end of the paper, and set the length stop. The machine is thus adjusted for the length.

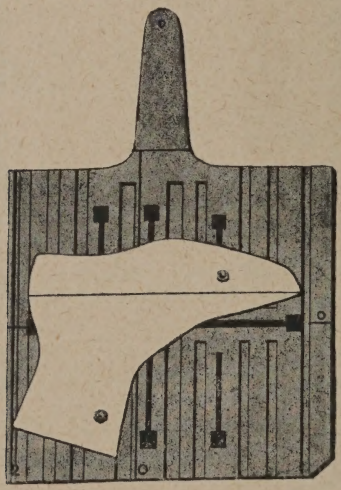


Fig. 144.

Now place the width measure level with the horizontal line running across the bed of the machine, and place the follower against the opposite end, as shown in the figure. Set the width stop.

The machine is now adjusted for width and length of uppers.

Throw back the clamps at back and front of machine. This will permit a large piece of cardboard to be placed in position.

Screw the model pattern to the table of the machine, taking care that the line running through the length of the pattern is approximately parallel with the horizontal line marked 0. Now proceed as with the soles.

In grading sole patterns upon this machine, a similar procedure is, of course, adopted, as before explained.

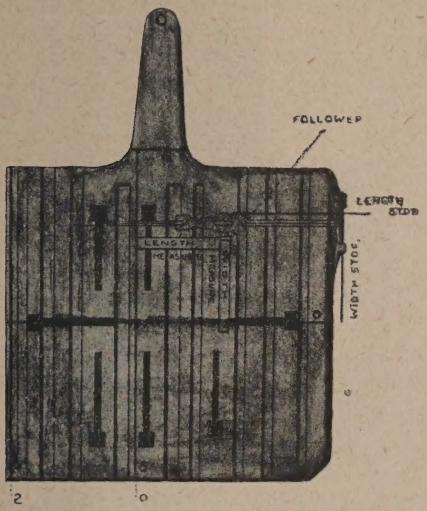


Fig. 145.

The initial pattern is placed over the length line, as shown in figure 146.

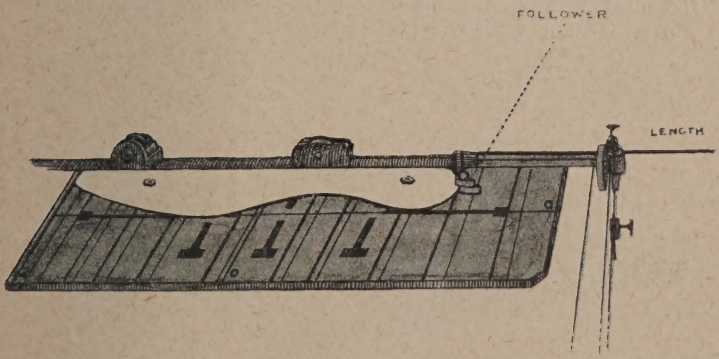


Fig. 146.

The follower is then brought up to the edge of the pattern, and the machine set for the required length difference. The pattern of the sole is then moved until its widest part

is over the line 0, a line at right angles with the horizontal length line. The follower is then adjusted to the side of

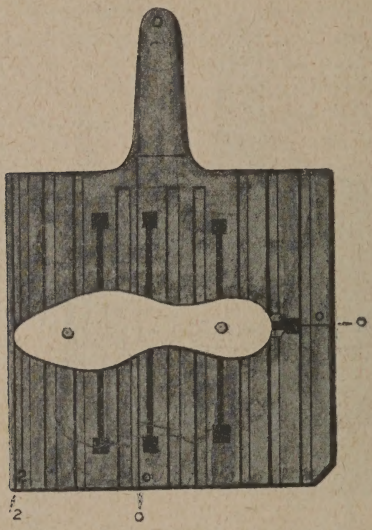


Fig. 147.

the joint, and the necessary adjustment of the machine for widths is then made.

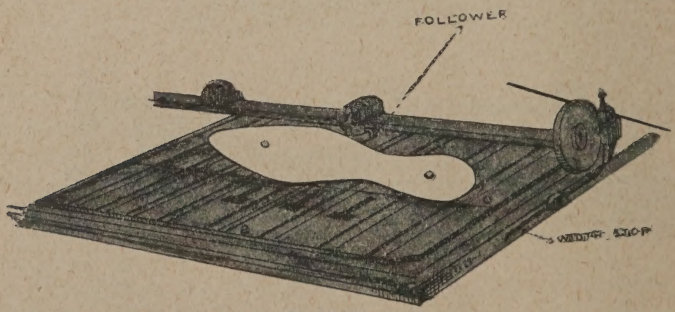


Fig. 148.

The sole shape is clamped down securely, whilst the material from which the patterns are to be cut is held down by the frame on the opposite side of the machine. These

are produced by placing the follower close to the edge of the pattern and causing it to travel quite round it, when the pattern, graded with the necessary differences, will be produced on the other side.

The latest development of pattern-making machinery is the noble "Reed Power Grading Machine."

The machine is specially designed for producing brass-bound millboard patterns, though the inventor claims that sheet metal patterns may also be produced by this invention. It marks an advance upon other grading machines

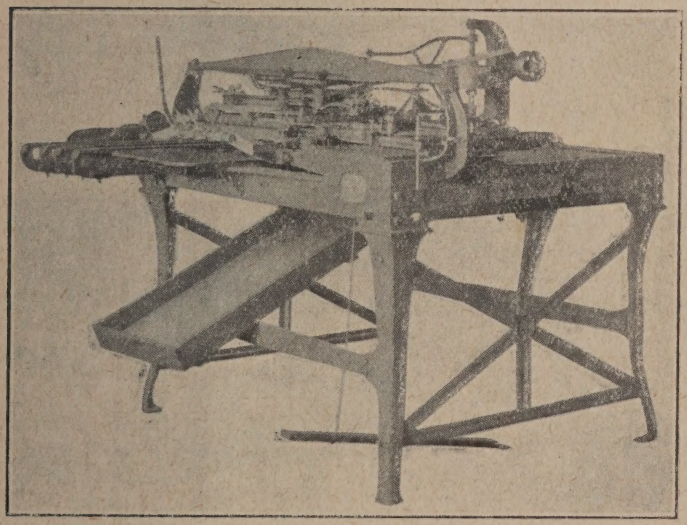


Fig. 149.

in that other grading machines employ either styluses or tracer-points in the place of cutters, so that under these systems the pattern is merely marked upon the material, being afterwards cut out with shears; or else cutter-knives are employed, which do not cut quite truly to the pattern, particularly at the corners.

In the "Reed" these objections are overcome by employing a reciprocating punch in place of a stylus or cutter knife. The punch is of the same diameter as the tracer, and operates with a die to produce a clean cut of the material. It is, moreover, reciprocated at a speed which causes the punched holes to overlap, or interlink, and so produce

a continuous cut. The edge of a pattern so produced, though serrated, may, if of metal, be smoothed with a file; or, if millboard, be rendered smooth and even by the application thereto of a metallic edging.

In its broadest sense this machine consists of a support

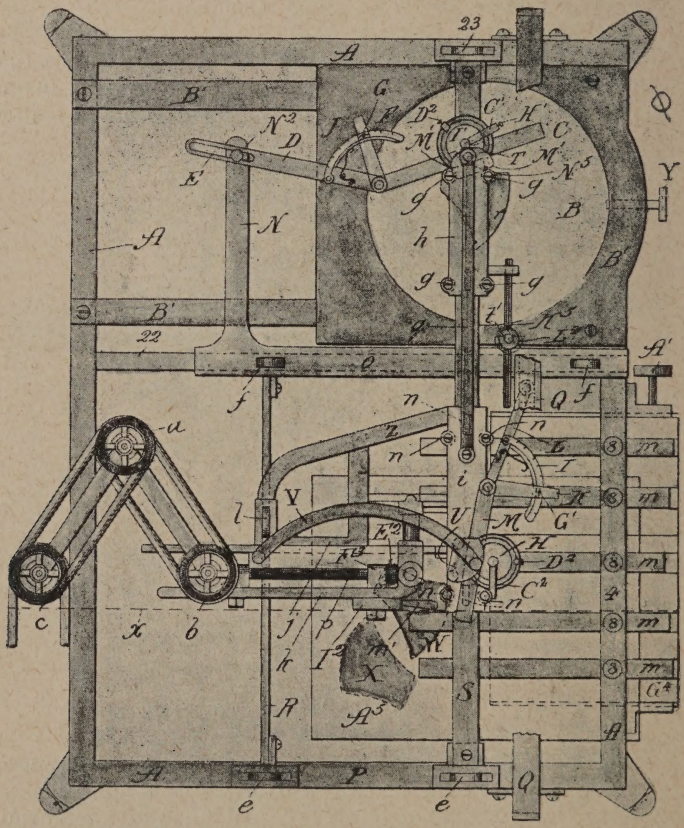


Fig. 150.

for a profile pattern or model; a support for a sheet of pattern material; a pantographic frame provided with a tracer and with a cutter consisting of a die and a reciprocating punch.

The apparatus also includes a provision in the pantographic mechanism whereby the adjustment for grading the patterns may be quickly and accurately made.

It will be seen that the machine grades and cuts out the pattern in one operation. The greatest variety of work can be accomplished upon it. "Facing and topband patterns can be graded all one width, inlaid facings can be graded one width, and all the grade put in the quarter. The grade on a set of patterns can be condensed to one-sixteenth of an inch in height, between sizes, or less, and it is claimed that a single operator can with ease average 500 pieces per day, graded and cut ready for binding. That is to say, it does work equivalent to at least three men on any other system.

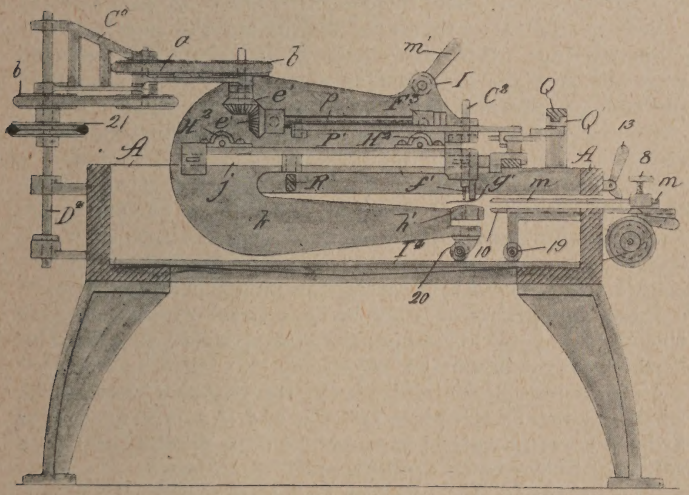


Fig. 151.

Figure 149 is a perspective view of the latest form of the "Reed Machine."

Figure 150 is a plan of the top of the machine with parts broken away to expose details which would otherwise be obscured.

Figure 151 is a sectional elevation on line x of figure 150.

The remaining details are shown in the other drawings.

A change in the pantographic mechanism to vary the relative movement between the stylus or tracer and the cutter in the vertical direction in figure 150 is effected by turning the wheel I1 to move it upon the rack C. Turning the arm C1 while the dog F1 G1 engages a tooth of the wheel I1 turns the latter and the pinion K1 to move the frame

L^1 upon the rack C and effect the change in the pantographic mechanism stated. In the end of the arm C^1 is a set-screw H^1 adapted to bear against the rim of the frame L^1, whereby, after it has been swung to turn the wheel I^1, it may be locked rigidly against further movement.

On the frame L^1 are two adjustable stops D^2 adjustable to regulate the throw of the radial arm C^1. A cap T, forming a rigid portion of the frame L^1, extends part way over the wheel I^1, and on the cap are rollers M^1, which bear against the outer or smooth edge of the rack-lever C and hold the teeth in mesh with the pinion K^1. A reciprocating carriage h (figure 150) is provided with anti-friction rollers g and fitted to travel readily on the bar S of the main carriage. The rack-lever C is pivotally connected with the carriage h by means of a downwardly extending pin or lug h^1, forming an integral part of the rack-lever.

On the bar S is a carriage i, provided with anti-friction rollers n, which travel upon the said bar. The rod q is pivotally connected at its opposite ends, respectively, with the carriage i and with the cap or head T on the frame L^1, whereby any change in motion of the carriage h in the vertical direction in figure 150 is communicated to the carriage i. The carriage h carries the stylus or tracer N^5.

Z is a supporting or brace bar connected at one end with the carriage i and at its opposite end provided with a roller l, which travels upon the bar R

In drawings 2, 20, and 21, K represents a yoke head, which, by means of rollers II^2, K^1, and i^1, is arranged so as to have a reciprocating movement on the track j, and by a roller 20 to travel on a platform I^4.

This bar, or track, J, forms a part of the main sliding carriage of the machine. The platform I^4 is a part of the main frame.

Any change in the adjustment in the part V on the bar M towards or away from the fulcrum i^2 of the bar, effected by turning the wheel H, changes the pantographic mechanism in a manner to vary the relative movements of the tracer point or stylus and cutter in the horizontal direction in figure 150.

The relative sweep, or movement, of the cutter in the direction from front to back of the machine is increased by adjusting the part U towards the free end of the track M, and diminished by moving the part U in the opposite direction upon the rack

Thus it will be seen that three distinct movements are provided for:—

(1) Of the main carriage transversely of the machine.
(2) A movement by means of the carriage i and h longitudinally of the machine.
(3) A reciprocating movement of the yoke K independent of the movement of the main carriage.

In drawing number 151, h^1 represents a convex die, which is provided with a vertical hole corresponding to the diameter of a round punch, f^1. The punch f^1 is supported in a post, C^2, having a vertical bearing in yoke-head K. An angular connecting rod, $A^2 B^2$ engages the post and is pivoted to an eccentric E^2, concentrically connected with a shaft p, and is driven thereby to give to the punch f^1 a vertical reciprocating motion. Means are also provided that while the punch is reciprocating, it may be raised above the material and prevented from cutting. The shaft p, by means of the pulleys a b^1 c and the gear e^1 is caused to rotate and rapidly reciprocate the punch f^1.

The table for holding and adjusting the material A^5 to be cut is shown at G^4, and in it are formed a series of dovetail grooves, 18, in which are mounted two-pronged clamps, m. The lower prongs, 10, of the clamps slide in the grooves 18 of the table G^4, and the upper prongs slide in rabbeted grooves formed in the under face of an upper cross-bar 4. The bar 4 is secured to the table G^4 and is tapped coincidently with the clamps for set-screws 8. The clamps may be adjusted longitudinally by sliding them in their guides in the table G^4 and cross-bar, and when adjusted may be fastened against movement by means of the set-screws 8. Extending transversely across the table G^4, and rigidly secured thereto is a bar, 14, and pivoted upon the bar at each clamp m is a cam-lever, 13. When the levers are turned in the downward direction, the cams press upon the upper prongs of the clamps and cause them to be pressed at their teeth 17 firmly against the material A^5, which extends between the prongs. The table G^4 is mounted in guideways, 15 forming a part of the main frame of the machine, and to the table is attached a rack, 7. The ways are provided with bearings for a shaft, 21, on which is mounted a pinion 6 engaging said rack and provided with a wheel, A^1. Turning of the wheel A^1 moves the table and material carried thereby in the direction transversely of the machine, or horizontally in figure 151. Rigidly connected with the carriage h is a rod, K^5, extending through a guide-block, L^4 mounted on the bar O. In the block is a set-screw, t^1, which may be turned to clamp

the rod K^5 to the block L^4. In changing the adjustment of the pantographic mechanism it is desirable that one part thereof shall be held rigidly against movement while the other part is being adjusted, and the rod K^5 and the means for locking it in place effect this purpose.

In operation it is best to use a sheet-metal pattern from which to grade. It is represented by the letter R in the drawing, and should be placed as there shown upon the table B, and fastened firmly in position at the slots 2.

The pantographic mechanism is then adjusted as follows:—

The set-screw G at the segment F is loosened and the arm J adjusted along the segment in accordance with the scale marked on the segment to cause the arm or lever 5 and rack C to extend at desired angles with relation to each other. A change in angle between the rack C and arm or lever D effects a change in the distance of movement of the punch or cutter f^1 with relation to the movement of the tracer in the direction longitudinally of the machine, which is the vertical direction in figure 151, thus permitting the operator to change quickly the length of the pattern in that direction. The wheel I^1, which is termed a "directing wheel," is turned to assume a desired position with reference to the rack C.

Presuming that the operation is to start by cutting out a pattern of the largest size desired, and then patterns grading down to the smallest size desired, the rack C and arm D will be adjusted to an angle which will cause the rack, when engaged at one end portion by the wheel I^1, to give to the cutter or punch f^1 the greatest sweep desired with relation to the movement of the tracer in the direction lengthwise of the machine.

Assuming the patterns to be graded are to present a difference of one-third of an inch between the grades for length.

To effect this difference, the stops D^2 at the wheel I^1 will be adjusted so that in the movement of the radial arm C^1 from one stop to the other the wheel will be turned to move upon the rack C a distance which will effect a variation of one-third of an inch in the movement in the said longitudinal direction of the cutter with relation to the tracer. The arm or lever L and rack M are then adjusted to a desired angle with relation to each other in accordance with a scale upon the segment I, and the wheel H is rotated until it engages the end portion of the rack M, in order that the movement or sweep of the cutter may be to the

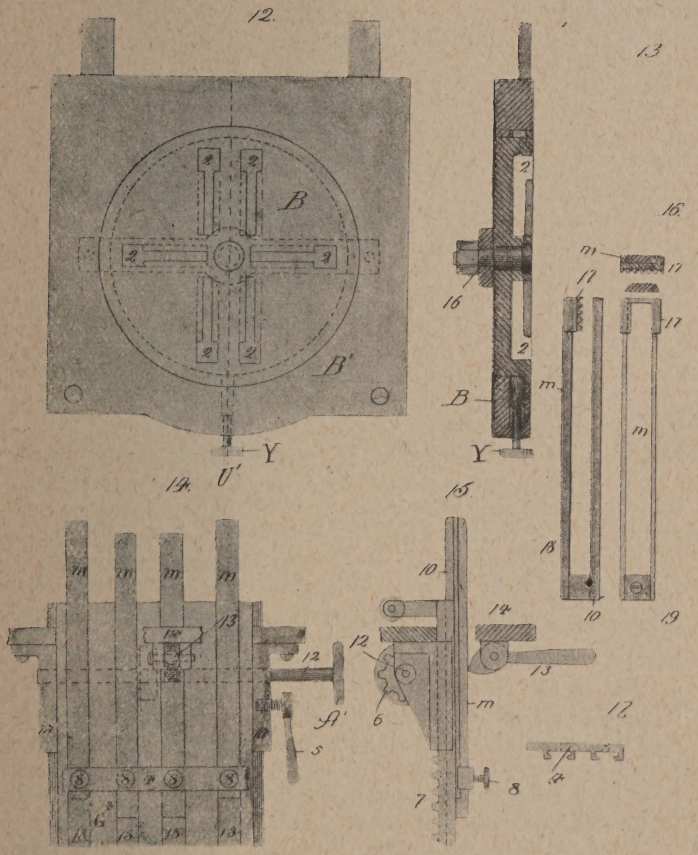


Fig. 152.

REED GRADER.

12, a plan view of a stationary table showing a reversible model, or profile-pattern support mounted therein; 13, a sectional view, line U, of 12; 14, a broken plan view of the adjustable supporting table for the material from which the patterns are cut; 15, a sectional view of same in side elevation; 16, a sectional view of one of the clamps for holding the millboard; 17, a broken elevation of a bar in which the clamp is held; 18, a side elevation of the clamp; 19, plan of the same.

greatest distance desired with relation to the movement of the tracer in the direction transversely of the machine. Patterns of the class shown are usually caused to vary one-quarter of an inch between grades in the direction in which change is effected by this adjustment, and the stops D^2 should be so adjusted that in the movement of the radial arm C^2 between them the wheel H will be turned to move it upon the rack M a distance which will change the transverse sweep of the cutter one-quarter of an inch with relation to the sweep of the tracer. The material A^5 is then passed between the clamps and between the die h^1 and foot g^1. The cap T is then grasped by the operator and moved to cause the tracer to engage the edge of the pattern r. The operator then turns the handle m^1 to lower the die-stock C^2 and punch f^1, so that the latter will reciprocate into and out of the die h^1 and in each downward movement punch a hole through the material A^5. The cap T is then moved to cause the tracer to follow the outline of the pattern r, whereby the pantographic mechanism causes the yoke k to pursue the same course and cause the punch to cut holes in the material A^5 along a line of exactly the same contour as the pattern r. The punch is caused to reciprocate so rapidly that the holes it produces intermesh or overlap. Thus in the movement of the punch a continuous cut is produced. When the tracer has traversed completely around the pattern r, a pattern X will have been cut from the material and drop out of the way. The handle m^1 is then turned to raise the die-stock and punch, so that in the reciprocation of the latter it will move in a plane above the material. The clamps m are then loosened and the material moved along to present a new surface from which the next pattern is to be cut. As the next pattern is to be a grade smaller than the first, the dogs F^1 G^5 will be moved to release the wheel I^1, the set-screw II^1 will be loosened and the radial arm C^1 moved to the opposite stop, D^2, after which the dog will be released, so as to engage the wheel I^1, and the arm C^2 will be moved back to the initial stop D^2, whereby the wheel I^1 is turned to slide the rack C and effect a change of one-third of an inch in the sweep of the punch with relation to the tracer in the longitudinal direction. The wheel H will be turned in the same way to change the adjustment of the pantographic mechanism and effect a change of one-quarter of an inch in the relative sweeps of the cutter and tracer in the direction transversely of the machine. The operation may be continued until adjustments have been made to the limits of the lengths of the racks C M.

Whenever it is desired to shorten or increase the length of the pattern being cut with relation to the profile-pattern, and without varying the relative width, the operator may, after moving the tracer across the base and up one side of the profile pattern, change the adjustment at the segment J to shorten or lengthen the relative sweep of the cutter, and then, after moving the tracer across the upper edge of the pattern, change the adjustment back again. A variation in the width of the pattern being cut may also be effected at any time during the operation by temporarily changing the adjustment of the relative angle of the parts L M.

The table B is capable of rotating a one-half revolution, and may be fastened at either limit of its movement by a set-screw or pin Y, which passes through the edge portion of the bed-plate B, as shown. Thus, when one pattern has been cut, the pin Y may be loosened, the table B turned a half revolution and the pin tightened again, whereby the pattern r is reversed between operations to economise material, as is indicated by the dotted pattern X W in figure 152.

Chapter XI.

VARIETIES OF PATTERNS.

The fundamental standards for men's, women's, and children's patterns having been dealt with, it becomes necessary now to deal with the divisions of these patterns into their parts and with the representative variations of these patterns.

The prevailing types of footwear for ladies' work are represented by:—

(1) The Balmoral or lace boot.
(2) The Button boots.
(3) The Oxford shoes.
(4) The blocked or whole-fronted patterns.

In men's work the representative patterns and their divisions to be dealt with are as follow:—

(1) Men's lace, whole and piece goloshed
(2) Men's button boots.
(3) Derby or block-fronted types
(4) Open-fronted or open tabs
(5) Long work—(a) Napoleon; (b) Wellington.

The Balmoral and the Button boot admit of variations also in their parts. For instance, they may be made seam to toe, vamped, or goloshed. Any one of these variations constitutes a somewhat different synthesis in the parts of the patterns as resolved from the original standard from which they are all derived. A difference is also made in the lengths and general proportions of the vamp as between a boot and a shoe pattern. The shape of the toe enters into the problem and determines in part the shape and extent of the opening. In bespoke work some wearers prefer the vamp to come well over the tender joint (in the case of a bunion), whilst others prefer the vamp should come below the tender point.

The fact to be remembered is that this defect always occasions a difference either below or above the standard vamp length. The greater the height of the heel, the lower the vamp in conformity to the principle that the raising of the heel shortens the forepart. Other things being equal, the capped vamp is higher than a plain vamp.

Differences in the last formation demand differences in the type of the vamp. If a pattern be cut with a very high vamp, then the last itself must have a very sharp comb, otherwise it may be impossible to get on to the foot the boots made upon the last with a high vamp.

Although it may be desired to have a vamp a fixed and pre-determined length from the toe, it is only possible to assure this by fixing the point by a measurement from the back of the last. In fixing the vamp height, therefore, upon the original standard derived from the last for this (and the relationships fixed on it determine all the subsequent patterns), it is desirable to mark upon the last itself the points at which the vamp, and also the toecap, should reach.

It is quite obvious that it is possible with accuracy to measure a point, say, three and three-quarters of an inch from the end of the toe, upon the last. It is quite impossible to measure such a point in relation to the finished boot upon the standard pattern.

The stretch of the upper and the amount of its yield under the strain of lasting would vary

(a) with the method of lasting;
(b) with the character of the material of the upper.

These are factors complicating the problem; but, of course, the fatal one is the addition of too little or over much lasting allowance. If the upper came one size longer than the designer contemplated, the whole relationship of the parts is put out of gear. If, however, the length of vamp be determined by a marked position on the last itself, arrived at in conformity with a proportion to be discussed, then this degree of uncertainty is eliminated. One authority gives the proportion of vamp height to last length as "for women's and children's work, one-fourth for low and one-third for high vamp; and one-third for low and two-fifths for high in men's and boys' work."

Vamps too long in the wing, or the ends of which are not curved round, are needlessly expensive to cut.

When the last is of extremely twisted type, and by no

means even-sided, then it becomes necessary to cut right and left sided standards and, consequently, right and left sided vamps. This is readily done by cutting a vamp in accord with the even-sided procedure, using the larger of the two unequal patterns. Then, opening the vamp and laying it out flat, the toe of the lesser standard is made to correspond with the toe of the opened vamp, and the crease of the opened vamp to correspond with the front border of the standard. Pencil round the bottom of the second standard upon the opened vamp. Cut off the amount shown as a difference in the inner side, and the right and left vamp pattern is produced.

Procedure identical is necessary for the production of right and left golosh pattern. The initial pattern, however determined, can be reproduced in larger or smaller sizes by grading.

The Button Boot.—The good appearance of the

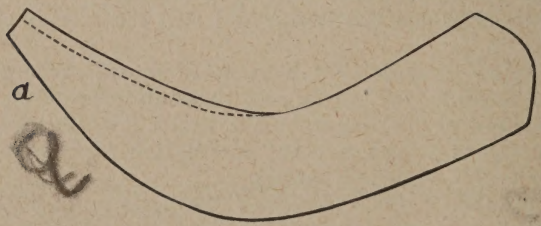


Fig. 153.

finished button boot depends very largely upon the maintenance of a correct proportion in the component parts. A very wide fly spoils the appearance, making a clumsy, heavy-looking product of what otherwise might be a graceful boot. The button fly should be widest at the top and gradually narrowed to the point where it meets the vamp. The initial width is best determined in relation to the ankle, rather than to the leg, measurement. Here one has a point that may be fixed with a fair amount of certainty; whilst the leg measurement may be a point anything between six and ten inches, and is of great variability. If the "button fly," or "button bit," be designed of a width of three-sevenths of the quarter at the plane of the ankle, with a gradual increase in width above that point, and a gradual decrease below it, that will be a safe rule to proceed upon. The greatest care is necessary to so cut the fly pattern that it shall lie as to its outer edge close

to the quarter, and yet form no ruck at the root of the fly near the vamp. This is done by altering the relation of the front line of the button fly to the quarter in such a manner that the line of the fly is less acute than the line made by the front edge of the quarter. This is shown in the following diagram, the dotted line representing the resulting form of the drafted button fly.

The procedure to procure the button fly is as follows: The standard having been procured, the height of the vamp is determined and marked thereon. The standard so marked is laid upon a plain sheet of paper. The front line of the standard is marked upon the paper from the point indicated by the vamp height to the top of the leg and along the top line of the standard. The widths of the button fly are then determined from the line so described. The deflection from that line is then made, constituting the "draft," as shown in the previous figure.

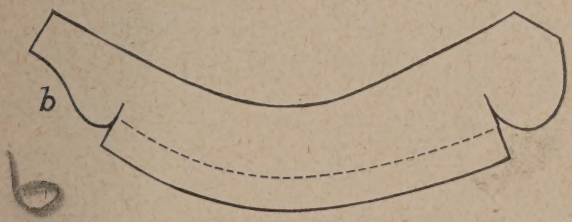


Fig. 154.

The remaining thing to be done, if the fly is to be scalloped, is to determine the size and shape of these scallops. When these are all the same gauge and shape, they are best produced by means of gouge or die representing that shape. By means of a tool of this sort the pair of flies can be produced at one operation in the clicking-room from a pattern designed in accord therewith. Even when the flies have graduated scallops the readiest method will still be to use two sizes, or three sizes, it may be, of such a tool. To produce the pattern itself to accord with the use of such tools the procedure will be as follows:—

Take the fly shaped as it results from the former operation and duly drafted. The first thing will be to shape the bottom scallop, i.e., the one nearest to the vamp. This being done, the button fly will then assume the form here shown.

Now take the dividers, opened to a width representing the width of the medium scallop, and set off a line parallel to the outer edge of the fly along its whole length, as shown in the figure. Now, taking the gouge or gouges, the terminals are placed to the edge of the line, and the tool pressed through the paper, and the necessary scallops are yielded. That is to say, all but the top and bottom scallops. We have already dealt with the bottom scallop. Sufficient material is left to design the top scallop in accord with the form given to the top of the leg.

The Oxford Shoe.—It is frequently asserted that there is more care needed in the design of the Oxford shoe than of any other pattern; that this is so that the shoe when made shall fit snugly at the sides, and so prevent the slipping up and down of the heel of the wearer. The fit of the shoe does not depend primarily on the pattern. What is necessary for the shoe is that

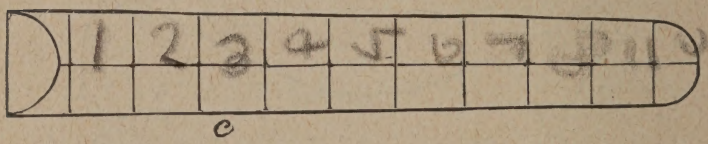


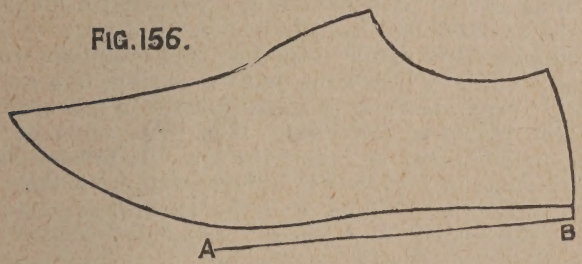
Fig. 155.

the pattern shall fit the last, and if the last be not properly designed and accurately formed, no amount of skill on the part of the pattern-cutter will obviate the initial defect. Having this erroneous idea, many pattern-cutters "hook on" the top of the quarter of the shoe pattern, and sometimes carry the pattern high at the back. "Hooking on" at the top results in broken back quarters when the old "top and bottom" last is used. If a broken last is used, there is less chance of this accident happening; yet, even so, the wearer will experience great difficulty in getting the shoe on, and then only with the great chance of the back developing a "concertina-like" form.

The great aim of the pattern-cutter must be to accurately fit the shoe last, and so close attention must be had to the correctitude of the forme from which the shoe pattern is to be developed. The general principles should include a low back, and in no case should the back height be more than one-fifth the length of the

last. The facing quarter should not be continued higher than one half-inch over the highest part of the instep of the last. The most essential point of all is, there should be a liberal lasting allowance upon the forme for the shoe pattern at the waist. Even though the waist of the last be very curved, the line of the pattern along the bottom, from the centre of the back of the heel to the commencement of the joint, should be almost exactly a straight line, as indicated in the line A B of the figure 156, representing a net mean forme. The lasting of the shoe depends upon an effective strain made lengthwise, and upon the very lightest stress vertically from the point of the instep to the waist. Only with a liberal allowance of material in the waist of the

FIG. 156.



last is this possible, and such must, therefore, be provided. By this means, also, it is possible to provide a properly shaped waist in the sole portion of the shoe, and yet not interfere with the success of the fit. Not to have too much sole stuff on the inside waist is very desirable also from the point of view of comfort, and for the welfare of the arch, especially in the case of the shoe. The purpose of the dome of the arch is to allow a protective area for the larger blood-vessels and nerves of the foot. Any hard substance, therefore, pressing against the foot on the inner waist tends to defeat the purpose of the structure there. There is a closer regard for the real needs when simply upper leather presses there, and this can only be accomplished by the restriction of the sole area of the waist, and this involves further the shaping of the lower edge of the shoe pattern as indicated.

The further type of representative ladies' work is that of the blocked front or whole-fronted patterns. The recent developments of this type of feminine footwear

make it desirable to treat the matter in detail. This type of shoe demands by the mere size of its parts that it shall be produced from the best materials. That the leather has to be wetted, stretched, and blocked into the desired shape renders good quality in the material an absolute necessity. Poor, loose materials would be quite unfitted for the purpose.

The vamps may be blocked either by hand or machine. The difficulties that have to be anticipated and provided for are concerned with the assurance of the correct height of the vamp and the relation of the overlapped quarters to the vamp itself, so as to ensure an easy entrance of the foot into the finished shoe. These things resolve themselves very largely into a question of the shape of the last. No amount of skill in the designing of the pattern will get over the difficulties referred to if the last itself is incorrectly formed. The pronounced sharp comb to the last, the maintenance of almost a straight line from joint to instep, is a necessity. It would be fatal to use a last with a marked fall from the instep to the joint. The room must be obtained by roundness of form; the same problems of last construction, in fact, are here met with as in the case of the child's strap shoe, and the student is referred back to the chapter on "Lasts" for a full discussion of this side of the question.

The difficulties are marked more deeply the higher the tabs of the overlapping quarters are situated from the toe. Such a long vamp, even though it is blocked to the desired shape, is only possible with the thinnest and best of materials. There is very little danger, therefore, of reproductions of these high-class designs in the cheaper materials and lower qualities.

Wherever efforts are made to reproduce the same design in a cheaper style, it is by dividing the vamp down the centre and producing a similar effect by a seam to the toe. Some quite high-class shoes are occasionally made by this method; the effect so obtained cannot be claimed to be as good as with the blocked front. What is possible thereby (and the method is for that reason sometimes adopted) is a closer fit and, possibly, less wrinkling of the shoe when worn.

Substantially, there is no difference in the method of pattern-cutting, whether the shoe be of the blocked front type, made seam to toe, or actually strained and blocked into shape.

pattern-cutting process, and calls for the production of a blocking pattern, in addition to the usual pattern for the component parts of the seam-to-toe shoe. These seam-to-toe patterns in the case of the blocked front are frequently used for cutting the vamp-lining of this variety.

The idea of the block pattern is to produce therewith from the skin or other material a piece sufficient to permit of the straining and stretching this process requires, and yet not wasteful of the material itself. The problem is to design a pattern to lie out flat, which, without waste, shall include within it the possibility of a curved form.

This blocked or whole-fronted type of shoe may be made to fasten with a lace or wide ribbon or with a buckle. In the lace fastening, or ribbon fastening, the front is generally entirely in a single piece. A variety of the same type is produced when, in a buckle fastening, the tongue is seamed to the vamp at that part of the vamp coming under the tabs and covered entirely by the buckle. In this variety the importance of sharp high comb to the last is more than ever marked, as the transverse seam tends to bind down and hold fast the entering foot at this point if the suggested provision in the last is not made. Material is saved, however, if this method is adopted, and if the front is not excessively high, and the shoe is well lasted, there need be no occasion to block the vamp, though there may be a need for blocking the tongue itself.

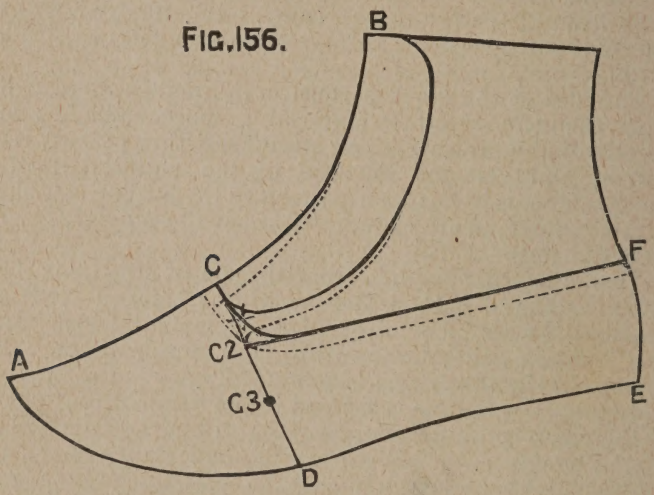
This seaming of the tongue to the vamp is not usual in the laced type, simply because this form permits the seam to show in nine cases out of ten.

In designing a man's lace-boot it is necessary that the front of the leg of the pattern above the ankle-point should be set farther back than that of a woman's standard, in consequence of there being a decided curve in front of the leg, and the upper usually not coming much above the ankle. The higher it is intended to clothe the leg, the less the inclination backwards, until we come to that clothing so far as the calf, where it is necessary that the front line should be more forward than the ankle position.

The usual procedure for determining the front line for this class of work is for a line to be drawn at right angles to the ground at a point measured from the seat equal to one-half of the last's length; but of this it will

be necessary to treat later. The throat must not be hooked in, and the student must always bear in mind

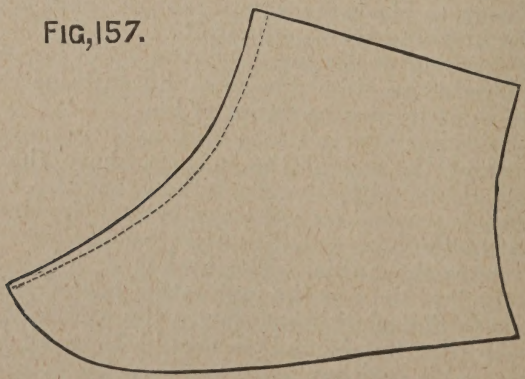
FIG.156.



that the pattern is flat, whereas the finished upper will be rounded to fit the curves of the last and leg.

A mistake frequently made in working to measurements is an intense desire for literal exactness

FIG,157.



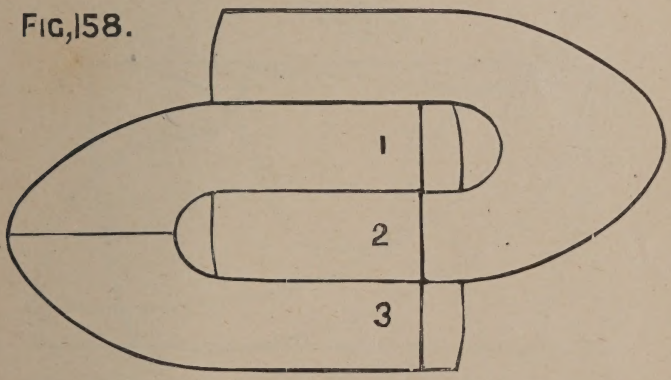
to those measurements, sacrificing contour, whilst forgetting that it is an area to be provided for. Were the desire for a series of location bands, the method would be excellent. The harmony

of curves must be thoroughly appreciated to obtain the best results.

The standard for a button boot should be slightly larger in measurement at the heel, ankle, and leg than that for a lace boot, and the comb of the last well rounded to obviate the pressure of the buttons. Various dimensions are given by different authorities to regulate the width of the button-piece; certainly, it should not be less than one-third, nor greater than one-half, of the leg width, and special care should be had that it be not too narrow from the throat to the golosh.

To prevent the outward curling of the button-piece it is sprung—i.e., the line of curvature of the front seam is altered, thus reducing the length of line of the outer

FIG. 158.



edge, causing it to curl under, gripping the quarter (Fig. 156). To get good results, the button lining and the lining should be whipped whenever possible. The inside (or button) quarter should be cut away an amount of about $\frac{3}{8}$in. at the top, and graduated to zero at the point just below the vamp (Fig. 157), thus ensuring levelness beneath the button fly seam when closed.

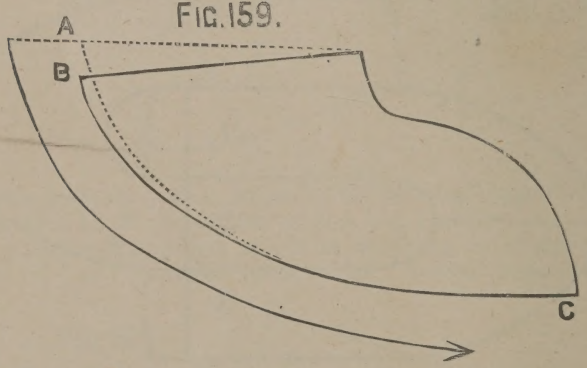
The designing of the golosh will depend considerably upon the work to be produced; if for patent, no spring is given; if for interlocking purposes, it will be necessary to divide the pattern at the determined vamp height into three equal parts, and for one part to regulate the opening and the depth. This will allow the goloshes to interlock as shown in Fig. 158.

The first method (Fig. 158) will need no explanation

as to designing. The height of vamp and depth desired are determined; the material is cut out dead to standard, and the amount taken off the back for pulling over in fitting plus $\frac{1}{8}$in. at bottom for stiffening.

For the interlocking process proceed as follows:— Determine height of golosh C (Fig. 156), draw C D at right angles to pitch line; divide C D into three equal parts, one part of which, C 2, will determine the width of opening, and also the depth of F measured from E. Take a sheet of paper, crease it, mark off from C an amount equal to C2, describe a suitable curve, and cut out; place it on standard touching C and A and mark from A to D; then, using x as the pivot point, drop it to F and complete. It should then be shortened for

FIG.159.



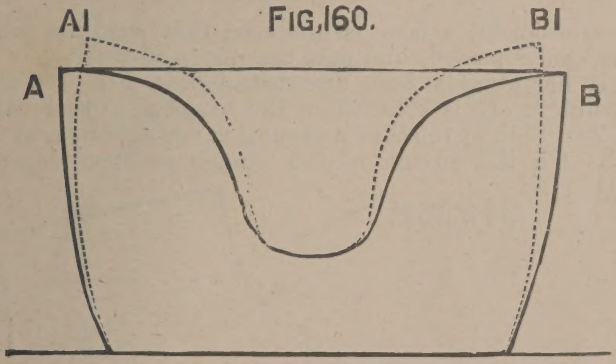
pulling strain in fitting, and the necessary allowance made for the stiffening. The golosh can be either whole, pieced, three-quarter, jockey-back, or strap and golosh in one, for the highest-class trade.

The effect of springing the golosh is to increase the length of the bottom line and to decrease the length of the top, thus causing a gripping effect along the range of the golosh, and a fulness along the feather (or bottom), rendering lasting more difficult, especially in the case of harsh leathers, such as patent, and principally so about the toe.

A golosh cut dead has the opposite tendency, and if too dead, grips the feather very closely, especially at the waist. This can be seen by observing figures 159 and 160, the dotted lines denoting a vamp with much spring, and the solid line the same cut dead. In Fig.

159 the distance from A to B represents the extra length of line obtained by the sprung pattern; and in Fig. 160, viewed from another aspect, the same result. It will be noted that the dead pattern gives greater width across the opening A to B than the sprung pattern at the same points A1 to B1.

Applying this deduction of line length to the cutting of shoe standard, it will be very obvious that to cut a shoe very dead is disastrous. The more the unfortunate laster endeavours to last it, the more hopeless is the result, which, to use the term in a technical sense, is a "lifeless thing." This "life" in the finished product is one of the subtleties of boot and shoe manufacture.



The Derby offers to the designer a variety of shapes for the lachet or tab, and, if the pattern is well designed, can be made one of the most popular of favourites for the smartest footwear as well as for heavy shooting wear.

Fig. 161 gives a few of the usual shapes of lachet. There is always a source of weakness at the fastenings of the tab, which to a great extent can be minimised by adopting No. 3 (Fig. 161). As the Derby has several substances (vamp, vamp lining, quarters and lining, and fold of tongue) at the instep, it should be made on a full rounded, combed last, to prevent any undue pressure upon that part of the foot.

The demand to-day is for a long-vamped Derby, which renders it imperative that whatever draft is put into the upper to give it a live appearance when finished must be given at the back portion. The vamp, to ob-

tain the necessary width across the opening, must be more dead than the standard. The design demands that the vamp where it joins the tongue shall be as large as the last at that point. If this important factor

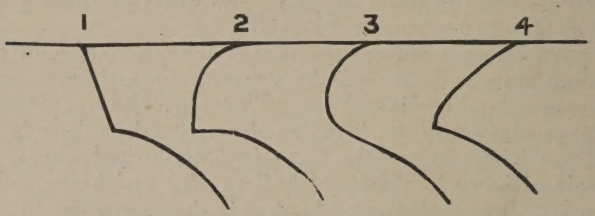
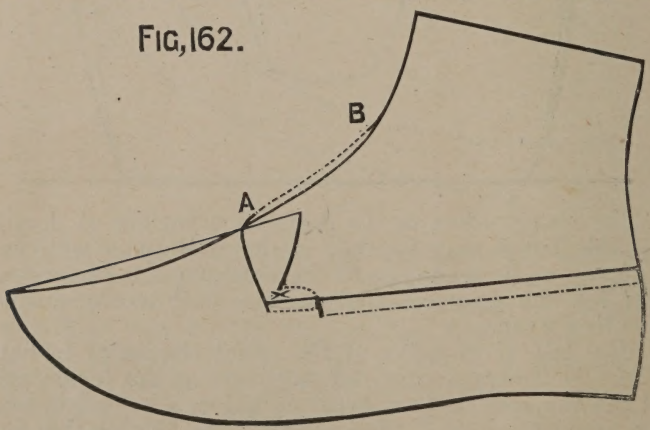


FIG. 161.

is overlooked, a boot is produced that wrinkles when the foot is passed, and cuts the instep in wear.

It has already been demonstrated in Fig. 160 that greater width is obtained at the wings of a dead vamp at A B than at those of a sprung vamp as shown at A1 B1. On the solving of this simple problem depends

FIG, 162.



the free, easy-fitting Derby boot, clear of all unsightly creases.

Necessary allowance to accommodate the seam of vamp and fold of tongue should be made at instep and heel; also at ankle and leg, if a whole bellows tongue is used. These, like all allowances, are regulated by the substance of material used. The design is best finished off with a back strap.

The open-tab boot is probably one of the most difficult of all designs to cut. The important point to remember is that all the parts meet and cross at the inner corner of the tab. The length and depth of tab are according to the taste of the designer—say as Fig. 162. An allowance must be made at instep to heel, as shown by the dotted lines A B, to accomodate the substances underneath. The goloshes are designed as previously described, with the exception that to insist upon the interlocking system is to produce a pattern that will cut

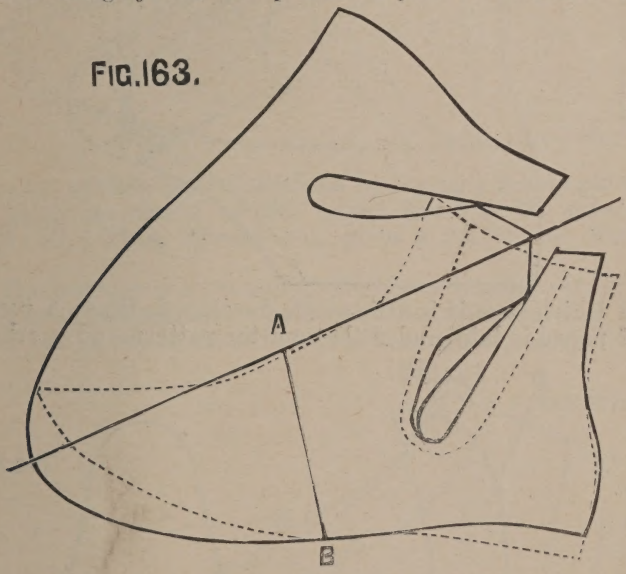


FIG. 163.

the instep of the wearer, unless it is for a very narrow fitting.

An amount for stay-stitching is allowed on that part of the golosh which is directly beneath the tab as shown at X on Fig. 162. The design is usually provided with a half-bellows tongue, and to obtain the best effect it should also form the facing at the lower part of same.

The castor for a military side-spring sufficiently explains itself (Fig. 163). This illustration should demonstrate the necessity of giving sufficient amount from the point A to B for all designs where blocking is necessary, the argument applying to Derbys and such designs which pass high upon the instep.

The cutting of the half-bellows tongue may present some difficulties; it may be cut in profile, as in Fig. 164,

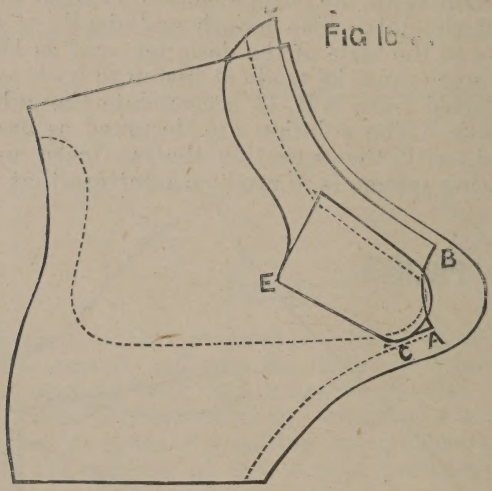


FIG 164.

in which case it is afterwards developed, thus: A piece of paper is laid under the quarter pattern and marked

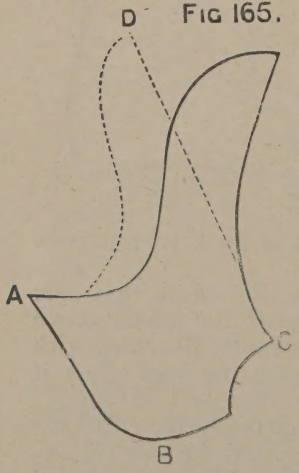


FIG 165.

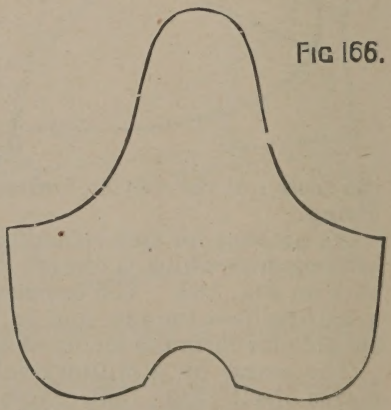
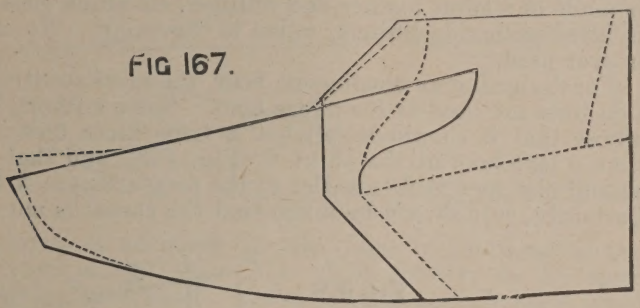


FIG 166.

down the front, then pricked through A and B to show where the vamp joins (sufficient allowance must be made for under-lapping). At the point C the paper should

then be folded level with the front edge, and the facing outline pricked through. The curve is completed as D E. This, when opened out, gives a pattern as Fig. 165, showing the tongue as it should be when blocked.

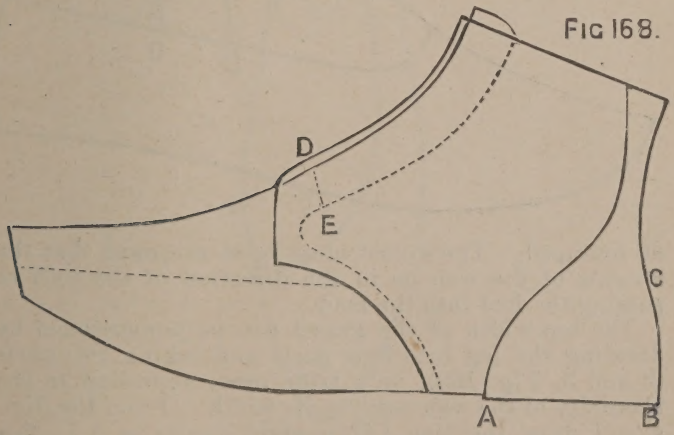
FIG 167.



The flat pattern can be obtained by laying a folded piece of paper (as shown by the dotted lines) at the points A B C D. This, opened out, gives a pattern as Fig. 166.

The blucher is a pattern of the block-fronted variety, and is sometimes cut whole back, in which case it is very low in the leg, and has but three eyelet holes (Fig.

FIG 168.



167), or it may be cut rather higher (Fig. 168) and seamed down the back, and has frequently a whole cut outside counter, which should be left very full at A B C to allow the insertion of the stiffener. In this latter

style the vamp is not quite as long as that of the older variety (Fig. 167). The vamp and tongue can be in one or joined, as shown by the dotted line D E (Fig. 168). The vamp is blocked. Usually this class of work is made of a stout leather and unlined, in which case it is fitted with side linings, felled to the vamp. No cap is ever used.

For designing an elastic-side boot, the same construction lines are used as for a lace boot. Some authorities advise that it should be pitched a trifle more forward than a lace boot at the point B (Fig. 169), and that it should also be a trifle smaller at the measurement A B. Certainly, care should be taken that the throat is not at

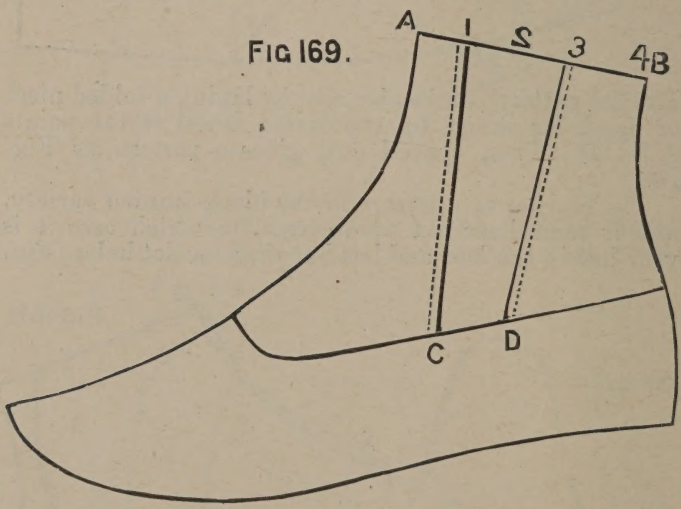


FIG 169.

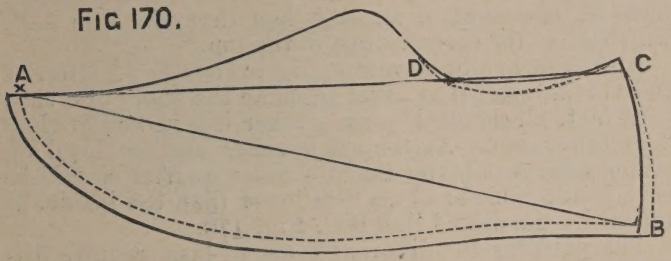
all cramped. The gusset must be so arranged that the strands of the web lie in the direction of the pull in passing the foot into the boot.

The top width of the gusset can be proportioned by dividing the leg into four parts and taking two parts (2 and 3, Fig. 169), or a trifle over, according to the elasticity of the web used, as its width. From the division 1 draw the line 1 C at right angles to A 1; this gives the front angle of the gusset. The bottom of the gusset should measure two-thirds of the top, which gives the point D.

For some inexplicable reason men are seldom to be

seen wearing shoes, whereas women prefer them. Is this the manufacturer's fault, apathy on the part of the

Fig 170.



retailer, or antipathy to that form of footwear by the average man? Certainly, shoes deserve to be more popular with men. Reference has already been made

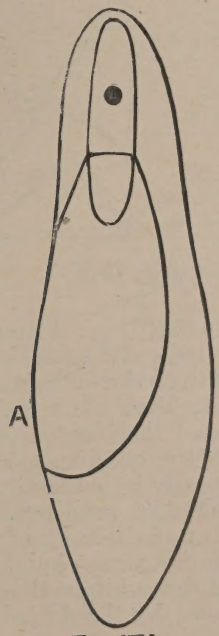


Fig 171.

that, to produce perfect-fitting shoes, correctly-designed shoe lasts are of primary importance; also that "hooking in" of the top of the quarter must not be resorted

to. A simple plan to correctly design the curve that a shoe should have at the back is to connect the points A and B, also A and C, Fig. 170. The line A C should measure one-third of an inch less than the line A B, which gives the correct draft to the top.

Although height of vamp must always be a matter of individual taste, it is usual to make the vamp of a shoe —in fact, all vamped work—rather less in height than a golosh vamp. As the ankle-bones are not level on either side, it is better that the outer quarter should be cut about a quarter of an inch lower than the inside, as shown by the dotted line D C, Fig. 170.

The patterns for different types of lasts require different treatment; for instance, a "twisted form" will need decided right and left patterns cut. It will be

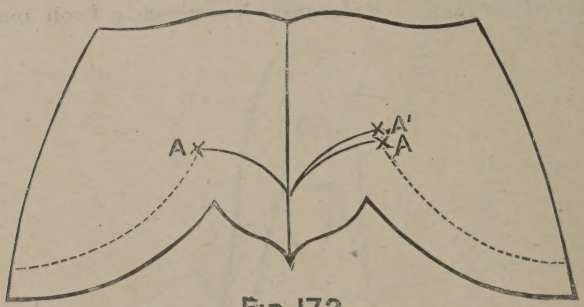


Fig 172.

found that the inside half is much smaller than the outside. A last of the type of Fig. 171 has a greater line length on the inside than the outside, in consequence of the prominence at A, Fig. 171: it follows, therefore, that the counter line of the inside quarter must be that amount greater than the outside.

This amount can easily be ascertained by marking on the last the height of vamp required, and then measuring from a fixed point at the back of the last (as previously explained) to the vamp height. The pattern should be corrected by adding the difference to the inside quarter as shown by the dotted line at C B, Fig. 170.

This type of last necessitates in Derby-fronted work that this difference be added to the inside quarter at the bottom corner of the tab, A 1, Fig. 172, for the tabs to be true when lasted. Although these amounts may

be in themselves very trifling, it is very important that they should be considered if the highest results are desired.

Toecaps should be designed with a slight bow, as the strain of lasting will straighten them.

Whenever drafting is necessary, the mode of procedure is as follows:—Trace the pattern on a sheet of paper, marking the joint position A B, Fig. 173. The amount of draft is decided upon (say, 3-9in. for light work, 2-9in. for stout work, and 1-9in. additional on

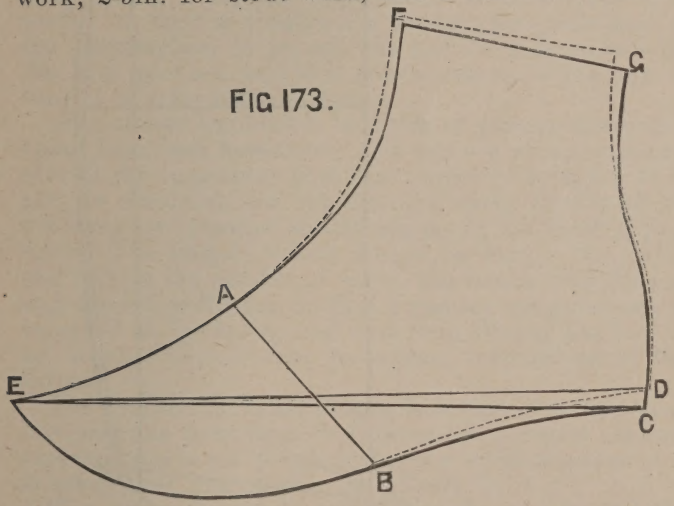


FIG 173.

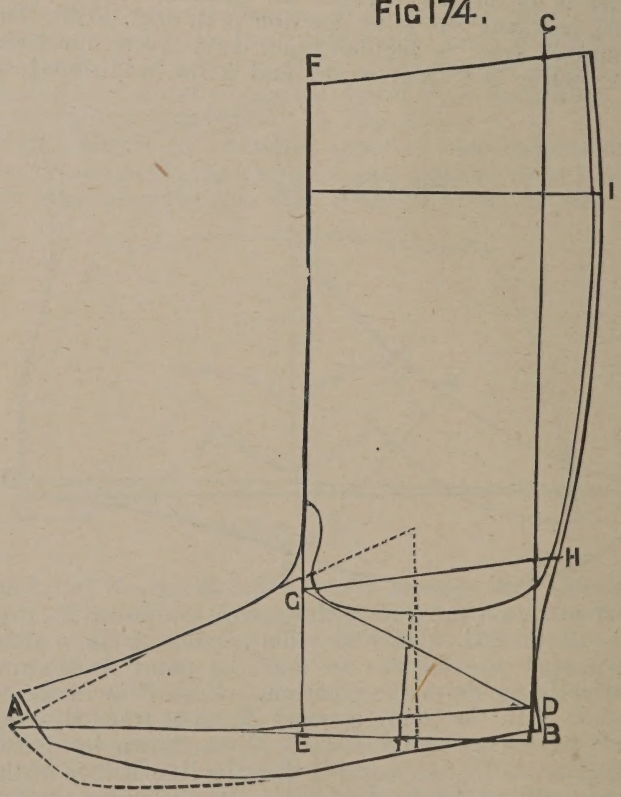
either amount for shoes); this gives the point D (Fig. 173). Join E C, also E D; then, using A as a pivot point, raise the pattern so that the point A remains practically in the same position, whilst C is raised to coincide with the point marked B; then trace this the whole back portion, A F G C B, as shown by dotted lines (Fig. 173) Be careful that the line E D is of the same length as the original E C.

It is advisable not to have too many seams to finish in one place; for instance, shoe linings are better if cut without a seam at the back.

Allowances must be made for all seams, underlays, and stiffeners. Remember that the lining should be smaller than the outside, in consequence of the displacement of the material when assuming a rounded form. In heavy material this is very considerable. An-

other point to remember is that the wider fittings of a range of lasts of any given length, if measured from the fixed point at the seat to the toe, show a greater length line than the narrow fittings. Thus, a pattern for a 5's fitting would necessarily measure longer than that for a 2's fitting.

FIG 174.



For pieced goloshes it is better to cut them with a slight bow which, gives a better drafting strain.

Long work is that which comes to the calf line; in some instances there is a special arrangement down the front which allows the foot to pass easily, and allows the ankle portion of the leg to be more or less fitted, such as the "Field" or "Sportsman." In others, although the leg is completely closed, it is made of

supple material, and the foot passes fairly easily—such as Wellingtons and Napoleons. In the third class the leg is closed, and in addition it is lined with a stout, stiff lining, or it may be made of one substance; whichever method is used, the endeavour is to get as firm a substance as possible.

The hunting, butcher, regulation, and coachman boots are of this class; sometimes the latter is made with a soft leg, but generally the stiff is preferred, the boot having a smarter appearance in wear when thus made. A boot so constructed necessarily needs care in the construction to permit the foot to pass, especially the heel portion, and this consideration is the key to the art of long-boot designing.

It is almost impossible to speak of pattern designing apart from last formation, and again a study is necessary of the important part that correctly designed lasts play in obtaining and maintaining those results which the designer intended should appear in the finished product. The long-boot last should be flat in the waist, and full on the outside of same. the instep well defined and carried well back, so that a greater measurement is recorded at the instep and heel than that of the foot to be fitted. This is done to prevent contraction at the throat.

The forepart is rather longer than that of an ordinary last, and the drop from the rise to the forepart abrupt; especial care must be taken that the waist measurement is considered (see chapter on "Lasts").

The instep should be set well in the centre, and the top part of the last above the waist and seat not too wide. The heel above the counter should be quite straight, and the seat full, especially at the breast.

For hunting-boots and the like, a $\frac{7}{8}$in. heel is used: for regulations and dress Wellingtons 1$\frac{3}{8}$in. to 1$\frac{5}{8}$in. This will, of course, necessitate difference in range and spring, but the main facts remain.

The upper when lasted on such a last will stand up straight, whether viewed from the front, back, or sides.

The butcher boot is designed as follows:—A base line, A B (Fig. 174), is described with the line B C at right angles. The height of heel is marked off in the same manner as for short work, which gives the point D. From the point B one-half of the last's length is taken, which gives the point E, from which erect the line E F at right angles to the base A B. The height of the

boot is determined, and a line drawn for the top of the leg; this should be higher at the back than the front, as the boot will drop mostly at the back during wear.

The heel is then marked off at the required angle, which gives the point G. From this point draw the line G H, the same length as D G (and at the same angle), thus making the angle D G H equal to the angle G D E.

The calf measure is then marked off at the given calf height (Fig. 174). Should this be omitted, the usual practice is to consider the height from the ground as equal to the full heel measure. Thus, if the heel mea-

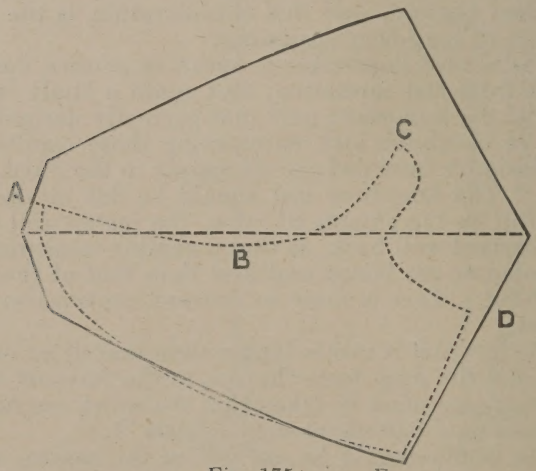


Fig. 175.

sure is given as 13¼in., the calf is assumed that height from the ground. The construction lines are now completed, and the forme may be used for sketching in the profile of the front portion.

The line passing from I through H to D should be as straight as possible, as the finished boot must have no suspicion of a bow in the leg. From the calf I towards C it should be nipped in slightly, as the leg is smaller here.

Sometimes abnormal measurements are given, such as a 13½in. heel, and the calf measurement an inch less; in such instances the calf must be made as large as the heel measurement, or it will be found impossible to get the foot in.

The key of the pattern is in the fact that the angle D G H is equal to G D E, which allows the passing of the foot. The case of a very flat foot having a heel angle of a very low degree, and of little extension, would require the angle D G H to be the greater, and the line G H longer than D G.

The front pattern is outlined as shown by dotted lines (Fig. 174). This pattern, when opened, is as Fig. 175; after having undergone the blocking process it assumes the shape shown by the dotted lines, A B C D E, in Fig. 175. The counter is cut whole back, and must be deep, measuring 2⅜in. to 3in. when the boot is finished for size 8's. It is joined to a back strap which covers the seam down the leg.

For the regulation pattern the top of the leg is cut with a curve as shown (Fig. 176). For some regiments

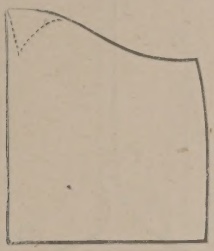


Fig. 176.

this is supplemented with a V-shaped cut; this is taken out somewhat on the inner side of the leg, so as to assume a level profile appearance with the rider who turns his toes outwards very considerably when in the stirrup irons (Fig. 176).

The hunting or coachman's boot is a similar one to that of the butcher, and is fitted with white or coloured tops. Usually a coachman's boot is made lower in the leg than a gentleman's boot; the small strap on the top of the latter is left loose, whilst for the coachman's it is stitched down.

It is essential that a lady's riding boot should not be cut proportionally as high in the leg as a man's, owing to the position that a lady assumes when in the saddle, which necessitates the leg being drawn up. If too high it will cut under the knee. For this reason many prefer the Hessian-cut top at A B in Fig. 177. The

material used for the leg is lighter, and has a thinner and less stiff lining than is used for men's work; the vamp and counter are often cut as shown at C D E, Fig. 177, especially when the Hessian-shaped top is used.

Officers' dress Wellingtons are similar to the riding boot, with the exception that the work is seamed down on both sides of the leg, and the leg is unlined; consequently the passage of the foot into the boot is less difficult. The height usually adopted for size 7's is about 14in., and it has a straight top.

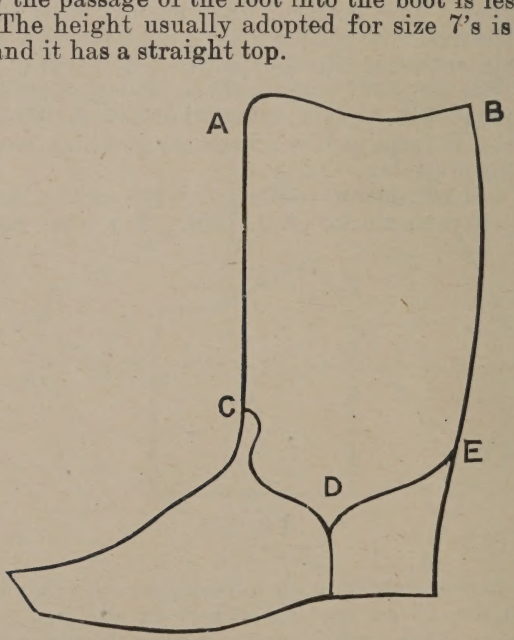


Fig. 177.

The procedure for designing is very similar to that for a riding boot, but, as the curve at the back has to be obtained by the shaping of the pattern at the side seams, it is here that the pattern differs. Take two pieces of paper folded as shown in lines A B and C D, Fig. 178, having previously sketched in a profile of the front portion on another sheet of paper.

From the point A the point E is determined by the length of counter required (generally 3½in. for size 7's, with ⅛in. difference between size and size). The calf width, F G, is now marked off. Up D G from the point

D mark off the counter height H, after providing sufficient allowance for lasting etc., as D 2. From H mark off the counter length, which gives the point I. From D 2 to J describe a line at the desired angle of the heel measurement. Deduct the half of the heel measurement (making full allowance for stiffener, lining, seat of last, etc.) from the gross measurement of the line D 2 J.

Mark off this difference from the point I, which gives the point K. Then from a point about 2in. below the

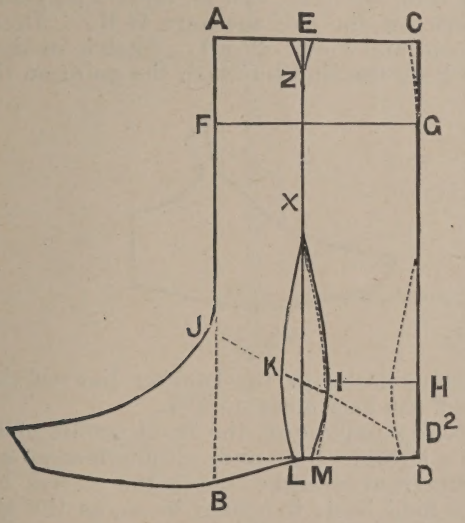


Fig. 178.

calf line (so as not to cramp the calf measure, and to maintain the symmetry of the boot) draw in fine straight lines to the points K and I. Continue the lines to L and M in the direction as shown, to allow the necessary freedom at the bottom of the pattern for lasting purposes. Sketch through the fine lines X K L and X I M suitable curves, making the curve X I M more acute than X K L. From Z (about 1½in. below the line A C) take out a V-shaped piece so that the leg, which is rather smaller than the calf, is fitted. This completes the Wellington; the side seams when closed should have a perfectly straight appearance. The back will assume the shape shown by the dotted lines in Fig. 178.

The counter is finished off with a point at the back, and the leg is furnished inside with a top band of about 5in. in depth. The tongue is cut as Fig. 179.

Wellingtons are also made with the entire vamp and front portion of the leg in one piece, in which case the back has an inside counter. The fronts for this kind of work are usually bought ready blocked.

The preliminary construction lines for a field boot are the same as previously described—A B the base (Fig. 180), B C at right angles, D height of heel, E half of last length from B. Through E, erect a perpendicular E F. Mark off the calf measure G H. Determine height of boot and mark off F I. Sketch in the cover forme, touching the line B C with the point on the pat-

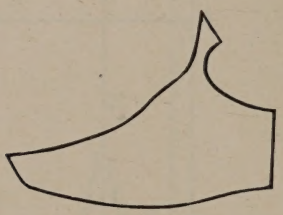


Fig. 179.

tern that coincides with the counter line on the last, and mark off the heel measure D J.

As previously explained, the front profile of the leg is far from a straight line, and, although some authorities give the front straight line as the correct line for designing a field boot, it cannot be so, as the simplest deduction will prove. Sketch in as shown from G to J, passing through X at the ankle line; care must be taken that the distance from X 2 to Z is not less than half an inch greater than the half of the ankle measurement to allow of the folds of the tongue, etc. Connect up all the points now obtained.

A good proportion for determining the length of the closed portion in the front is one-third (measured at the back) of the pattern's height. Necessarily, if the heel measure is out of all proportion to the calf, it will require modification, and the closed portion will be less. A position is determined rather in front of the centre line (say, one-third of the leg width) for the small slit. This need only be sufficiently deep enough to allow a free pass for the heel. A slight V-shaped piece about

⅜in. wide at the top should be taken out, so as to form a draft around the top. A buckle and strap are used to fasten the opening. The boot is fitted with a bellows tongue.

It is better to cut the leg patterns rights and lefts, leaving about ⅛in. at the points F and I, graduated to nothing towards the points G and H on the outside leg,

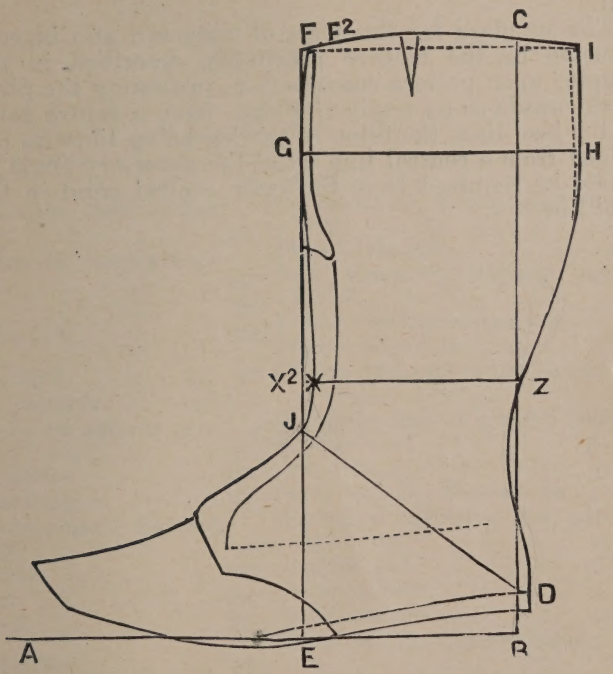


Fig. 180.

a like amount being taken off the inside. This has the effect of fitting the swell of the calf more perfectly, and the seam is straightened in consequence of the V-shaped gusset. The top of the leg is made about half an inch smaller than the calf, and is fitted better by designing the front of the leg with a slight curve from G to F. The point F 2, however, should not be set back more than ⅛in. from the straight line E F.

In wear—especially so in the case of a large, swelling calf—the top line of the boot is displaced; it is therefore

better to cut the top with a trifling bow, as shown by the solid line F I, Fig. 180, in preference to the dotted straight line. It is fitted with a full bellows tongue. Especial care must be taken that sufficient allowance is made at the ankle line for the passage of the foot. The vamp portion is the same as that of a Derby, or it may be cut with a golosh in the same manner as the open-tab Bal.

The standard for this class of work can also be constructed by the method previously described in the chapter upon pattern construction—assuming the pitch of the ankle as an angle of 90deg. from a centre point in the heel line, the pitch of the leg being likewise obtained from a central line set at the necessary angle as would be required from the same central point in the heel line.

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